POINTBLANK: ACTS ON THE EVE OF WAR, 1938-1939

BY

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APPROVAL

The undersigned certify that this thesis meets master's-level standards of research, argumentation, and expression.

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ACKNOWLEDGMENTS

I entered the History of Airpower I with no clue of a thesis topic. During the discussion of a book about the Luftwaffe it came to the class's attention the scholarship on the Air Corps Tactical School merely brushed the surface of this foundational institution. Our instructor suggested a few SAASS students should pick a year or two of the ACTS syllabus and explore it in depth. I took up the challenge. I thank Dr. Thomas Hughes, who directed me to a small portion of USAF history that I have thoroughly enjoyed. I also wish to thank Dr. Richard Muller for stepping in at the last minute to help complete this project. The literature review of this thesis would have suffered without his inputs, as would my knowledge of the Norden bombsight.

Throughout this process, I kept my sanity by riding bikes and running with classmates, thanks fellas. The conversations at lunch were riveting and I was glad I could make the majority of my classmates feel better about their theses as they gauged their progress on my lack of progress.

Finally, I would like to thank my daughter and my wife. My daughter kept it all in perspective with the smile on her face I saw every day and her own busy schedule, which I realized was more important than mine. She also completed her "thesis" before I did, a great accomplishment for a toddler. To my wife, I am truly amazed and motivated by your drive and tenacity. A SAASS student as well, she managed to have reconstructive knee surgery, survive the first trimester of our second daughter, and complete her thesis before me. She is my rock.

As this is my first attempt at any written work longer than 15 pages, I think I should finally admit that all inaccuracies are mine.

ABSTRACT

In 1942, American B-17s began populating the English countryside to do battle with Germany. The bombers were new and untested in combat while the crews that flew them were young and inexperienced, a recipe for disaster. In the opening months of 1944, the Allies needed to subdue the German war machine in France before they crossed the English Channel and hit the beaches. The interdiction campaign that ensued used bombers and fighters, some new and untested in combat with inexperienced crews, another recipe for disaster. The glue that held the Army Air Forces together during those trying times was the theory, doctrine, and tactics nurtured at the Air Corps Tactical School during the interwar period and embodied by AWPD-1. Airpower was not decisive by itself, but its absence would have decisively defeated the Allies. The Air Corps Tactical School provided the foundation that enabled an unprepared nation to meet its toughest challenge. This thesis explores the mature Air Corps Tactical School syllabus of the 1938-1939 school year through the lenses of the Air Force, Bombardment, and Attack courses. The aspirational Air Force course established a uniquely American way of air warfare that set the tone for the Army Air Forces. Meanwhile, the creativity of the Bombardment course developed planning methods critical to the success of the Combined Bomber Offensive. Finally, the Attack course portrayed an Air Corps struggling to find an attack aviation identity meeting both the requirements of the Army and its Air Corps.

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Introduction

The fighters are our salvation, but the bombers alone provide the means of victory.

Sir Winston Churchill

The ominous noise of jet engines pierces a calm, late afternoon in the desert as the sun begins to set. In flights of twos and fours, bombers and fighters taxi to the runway and await their clearance to launch. As they head north through the twilight sky, nervous aircrew, students of the United States Air Force Weapons School , mentally prepare for the "push" in anticipation of the most challenging peace-time tactical experience the United States Air Force (USAF) provides. Two thousand miles to the east, students at the Air Universitytackle an evening's reading assignments in preparation for seminars designed to challenge their knowledge and understanding of airpower theory and history. Both institutions' purpose is to educate and develop tomorrows' airpower leaders, but they accomplish their missions in different fashions. The Weapons School instructs company grade officers on the USAF's most advanced tactics, techniques, and procedures, honing the skills of air combat. Conversely, the Air University focuses on instructing field grade officers in the military operational art developing their understanding of why the United States needs airpower in the first place and how the USAF should use airpower. One institution, the Air Corps Tactical School (ACTS), did both on the eve of American airpower's greatest challenge.

A vast library exists on the topic of American airpower; yet no historian has authored a book whose subject is the Air Corps Tactical School. Robert T. Finney, a historian who worked for the USAF Historical Division of Air University's Research Studies Institute, authored a USAF Historical Study titled *History of the Air Corps Tactical*

School, 1920-1940 in 1955. Finney did an excellent job of capturing a chronological history concerned with dates, places, people, and administrative bureaucratic hurdles encompassing three-fourths of his study. His study failed to provide a thorough critical analysis and comment on the impact and significance of the airpower studies taught at this foundational institution.[1] Instead, he conducted a cursory examination of airpower theory and the implementation of that theory through strategic bombing, highlighted a struggle between bombers and fighters for supremacy without sorting out the details, and neglected the Attack section whose lectures most resembled Allied efforts during World War II. In fact, any discussion of ACTS' curriculum content was lacking.[2] Thomas Greer authored a USAF Special Study titled *The Development of Air Doctrine in the Army Air Arm, 1917-1941*, also originally published in 1955. Greer provided a better glimpse into the theory and doctrine contributions originating from ACTS, but does so in a broader study focusing on contributions from the entire Air Corps and the powerful personalities fighting for independence.[3] Greer, like Finney, failed to explore ACTS' other contributions that ultimately prepared the Air Corps for World War II (WW II). Two airmen have also provided a brief historical account of ACTS.

In *The Paths of Heaven: The Evolution of Airpower Theory*, Lieutenant Colonel Peter R. Faber contributed an essay titled "Interwar US Army Aviation and the Air Corps Tactical School: Incubators of American Airpower," originally published in 1997. Faber suggested the Air Corps developed a four-part strategy designed to convert America from a maritime nation to an airpower nation, demonstrate the flexibility

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[1] Robert T. Finney, *History of the Air Corps Tactical School, 1920-1940*, USAF Historical Study 100 (Maxwell AFB, AL: USAF Historical Division, Air University, 1955), 1-25, 40-43.
[2] Finney, *History of the Air Corps Tactical School, 1920-1940*, 26-39.
[3] Thomas H. Greer, *The Development of Air Doctrine in the Army Air Arm, 1917-1941* (Washington, D.C.: Office of Air Force History, U.S. Air Force, 1985), 47-67.

of airpower, gain independence, and develop a unique theory of air warfare.[4] While Faber sprinkled contributions ACTS made to the first three parts of his proposition, he did not focus on ACTS until he discussed the Air Corps' unique theory of air warfare. Faber identified three separate phases of ACTS history and provided an excellent overview of these three phases identifying the theoretical and doctrinal development that occurred at the school.[5] This study lies within Faber's third phase. Faber lightly touched on the subjects of targeting and intelligence, addressed in the Air Force course, but failed to explore any course in depth. His quick summations of all three phases yielded nine reasons why he thought ACTS' theory was flawed, but he failed to highlight the elements of the ACTS' syllabus that contributed greatly to America's war effort.[6] While Faber highlighted the bad of ACTS' theory, another only highlighted the good.

By 1972, Major General (retired) Haywood S. Hansell, Jr., an ACTS instructor in the Air Force Section in the mid-1930's and one of the authors of the first plan developed by the Air War Plans Division (known as AWPD-1), was frustrated with the current scholarship surrounding WW II. In an effort to highlight American air operations planning and strategy, he authored *The Air Plan that Defeated Hitler*. The preface stated the book was primarily about AWPD-1, but Hansell submitted he needed to review the theory and doctrine derived at ACTS, as it was pivotal in the development of the plan implemented by the United States over the skies of Europe.[7] Hansell provided a brief synopsis of the 1920's before settling in to his time at ACTS. He witnessed the tension between

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[4] Lt Col Peter R. Faber, "Interwar US Army Aviation and the Air Corps Tactical School: Incubators of American Airpower," in *The Paths of Heaven: The Evolution of Airpower Theory*, ed. Col Phillip S. Meilinger. (Maxwell AFB, AL: Air University Press, July 2010), 186-187.
[5] Faber, "Interwar US Army Aviation and the Air Corps Tactical School," 211-221.
[6] Faber, "Interwar US Army Aviation and the Air Corps Tactical School," 219-221.
[7] Maj Gen Haywood S. Hansell, Jr., *The Air Plan that Defeated Hitler* (Atlanta, GA: Higgins-McArthur/Longino and Porter, Inc., 1972), xi.

the Bombardment and Pursuit sections describing the personalities on both sides of the issue and the inability of ACTS to reconcile bombardment and pursuit aviation.[8] Unfortunately, Hansell fell well short of his potential given his pedigree and experience. After the discussion about pursuit he reverted to what he knew best, the theory of air warfare developed at ACTS. He used his first-hand knowledge to describe the forging of the ACTS' theory of air warfare and the personalities behind it.[9] Hansell also related a story on the origination of bombing probabilities, which became crucial to war planning.[10] Hansell never mentioned any other portion of the ACTS syllabus leaving plenty of questions for future scholarship. Hansell's efforts did not satiate the appetite of the historian.

The Air Corps' theory of strategic bombing receives a fair amount of criticism in the existing literature as authors attempt to debunk the concept leading to the independent USAF. The Air Corps at large deserves this criticism, but ACTS has become the fall guy over the years. Unfairly, authors often only identify the role ACTS played in developing the Air Corps' doctrine; omitting the positive role the overall syllabus played in American WW II efforts. Far away from what would later become the Beltway at Maxwell Field in Montgomery, Alabama, ACTS became the epicenter for higher thought on the application of airpower. ACTS worked in concert with the Air Corps Board to develop the unofficial doctrine the Air Corps summoned for their nation as the world raced towards war in the late 1930's.[11] Some claim the rhetoric of ACTS evolved into an unhindered expression of an independent strategic bombing theory.[12] The rhetoric of these claims is not a fair, and

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[8] Hansell, Jr., *The Air Plan that Defeated Hitler*, 12, 19, 22.
[9] Hansell, Jr., *The Air Plan that Defeated Hitler*, 30-48.
[10] Hansell, Jr., *The Air Plan that Defeated Hitler*, 16.
[11] Finney, *History of the Air Corps Tactical School, 1920-1940*, 16-17.
[12] Tami Davis Biddle, *Rhetoric and Reality in Air Warfare: The Evolution of British and American Ideas About Strategic Bombing, 1914-1945* (Princeton, NJ: Princeton University Press, 2002), 156.

certainly not a complete, assessment of the reality witnessed by an ACTS student.

ACTS was the most advanced professional military education school within the Air Corps. A small percentage of ACTS graduates attended the Command and General Staff School, but for many of the airmen, ACTS was the final school they would attend during their military careers.[13] Viewed through this lens, the Air Corps charged ACTS with the challenging task of preparing officers for the rigors of staff work and command. The Department of Command, Staff, and Logistics instructed on subjects such as combat orders, communications, logistics, intelligence, and staff duties.[14] The organizational and leadership skills acquired at ACTS influenced the methods by which the Air Corps planned and executed WW II.[15] ACTS taught vital organizational skills in the tactics courses as well.

Viewed through the lens the name suggests, ACTS taught tactics which they accomplished in many fashions. The Department of Ground Tactics instructed traditional ground force tactics such as combined arms, infantry, cavalry, field artillery, and chemical warfare in the fall semester of a nine-month school year. The Department of Air Tactics and Strategy did not interface with the students until the midway point in the program and instructed the tactics of bombardment, attack, pursuit, and observation aviation. Nestled in this department was the Air Force course, ACTS' sole course on airpower theory and strategy.[16] Neither department was perfect, nor could it be. The limits of time, equipment, and money did not enable ACTS to produce a graduate with

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[13] Finney, *History of the Air Corps Tactical School, 1920-1940*, 20.The Army renamed the Command and General Staff School to the Command and General Staff College, now attended by all field grade officers in the Army.
[14] Finney, *History of the Air Corps Tactical School, 1920-1940*, 21.
[15] Finney, *History of the Air Corps Tactical School, 1920-1940*, 24.
[16] Finney, *History of the Air Corps Tactical School, 1920-1940*, 21.

similar qualifications as a graduate of the Weapons School.[17] Instead, ACTS produced graduates with some of the necessary tools to organize, plan, and execute the air portion of the largest war ever fought.

The focus of this study is to explore the syllabus taught by the Department of Air Tactics and Strategy during the 1938-1939 ACTS academic year. The 1938-1939 academic year was a culmination of 20 years of academic trials, and represents the mature syllabus that concluded America's interwar years. The 1938-1939 year was also the last year ACTS offered the regular course. Sensing war was imminent, the Air Corps directed ACTS to administer four 12-week "short courses" during the 1939-1940 academic year in order to produce a larger pool of graduates to aid in the upcoming crisis. Germany's invasion of Poland sealed ACTS' fate. The Air Corps suspended ACTS after the 1939-1940 academic year to focus attention on the unprecedented expansion the Air Corps was undergoing.[18] Unfortunately, it is outside the scope of this study to compare multiple years of the ACTS syllabus. The depth of the courses requires a broader study with more time to devote to the differences from year to year. The Department of Air Tactics and Strategy itself is too broad for this study.

This study specifically focuses on the Air Force, Bombardment, and Attack courses of the Department of Air Tactics and Strategy. One interpretation of ACTS is that a battle raged between the Bombardment and Pursuit sections for status within the Air Corps. While relevant to the history of ACTS and important to gaining air superiority over the skies of Europe and the Pacific, pursuit aviation did not have an air-to-

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[17] Finney, *History of the Air Corps Tactical School, 1920-1940*, 18-19. ACTS flying was rudimentary compared to the current Weapons School. The Weapons School utilizes a six-month course to instruct aircrew only in each major design series (B-52, A-10, F-22, etc.) in the advanced tactics, techniques, and procedures of the USAF. Each course consists of academics and an intense flight program culminating in a simulated war-time exercise.

[18] Finney, *History of the Air Corps Tactical School, 1920-1940*, 40-41.

ground mission. Dropping bombs was the central theme of ACTS theory, and bombers and attack aircraft were the harbingers.

The following three chapters provide a thorough examination of ACTS doctrine and the role of the strikers. The Air Force course, taught last in the curriculum, was the culmination of the year's instruction in theory, doctrine and strategy for both an air campaign and the air campaign within the overall military campaign. The Bombardment course introduced the rudimentary methods used in modern weaponeering and taught the students to think "Big" when planning bomber missions. The Attack course explored the identity of the attack mission within the Air Corps, feeling the gravitational pull from both the Army and the Air Corps. Each course provided invaluable insight, without which the reality may not have existed to argue the rhetoric.

Chapter 1

The Air Force Course

No hope remains for the nation deprived of its [electric] power to maintain, to reinforce, or to replace its armed forces.

Major Muir S. Fairchild

The Air Force course, referred to by some instructors as the Air Warfare course, was the controversial ACTS course establishing the theoretical foundation not only for USAAF World War II doctrine, but also for modern day USAF airpower doctrine. The Air Force course consisted of 43 lectures spanning a month from late March to late April 1939 after the syllabus established a firm base in attack, bombardment, and pursuit aviation.[1] Sheltered from the politics consuming both the Army and its Air Corps, the Air Force course instructors used pure theory to lecture about the proper use of airpower focused on using bomber aircraft to coerce an adversary.[2] The ability to use airpower to bend the will of a state elevated the air arm to equal status with both the Army and the Navy in the minds of these pioneering airmen.

The fledgling Air Corps found itself suffering an identity crisis during the interwar period symptomatic of the absence of a cohesive airpower theory. The official position of the US Army subordinated the air arm to the ground force and tasked it to support the ground scheme of maneuver.[3] This mission set stood in stark contrast to the aspirations of ACTS described above. In the opening lecture of the Air Force course, Major Muir S. Fairchild argued this chasm existed because of the

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[1] ACTS, "Form 1" for the "Air Force" course, 1938-1939, in AFHRA, decimal file no. 248.2020A.
[2] Maj Frederick M. Hopkins, Jr., "Review of Air Warfare" lecture, Air Corps Tactical School, Maxwell AFB, AL,, 3 April 1939, in AFHRA, decimal file no. 248.2020A-15, 6.
[3] Robert T. Finney, *History of the Air Corps Tactical School, 1920-1940*, USAF Historical Study 100 (Maxwell AFB, AL: USAF Historical Division, Air University, 1955), 1-25, 40-26.

historical precedent afforded to land warfare. Ground commanders drew upon hundreds of years of war experience and well-established principles to develop campaign plans. An air force commander, struggling in the infancy of airpower, drew upon the limited experience of the past twenty-five years without well-established principles, introducing the potential for faulty logic in campaign plans.[4] Airmen needed to harness air power into a theory of air warfare to annul the ground commander's trump.

The 1939 term "air power" connoted a different meaning than the 2012 term. Currently, the USAF defines airpower as "the ability to project military power or influence through the control and exploitation of air, space, and cyberspace to achieve strategic, operational, or tactical objectives."[5] Fairchild described air power "as the immediate ability of a nation to wage Air Warfare."[6] He used the analogy of a naval fleet in being to highlight the importance of readily available air power, hinting at airpower's asymmetric advantage. A state with a robust air force defeated the state with an insignificant air force subsequently rendering that state's industrial base inconsequential.[7] Even in 1939, aircraft were complex machines with acquisition cycles spanning years.[8] A large standing air force was essential if a state wanted to absorb an attack and then wage air warfare.

The 1939 term "air warfare" has much in common with the 2012 term "airpower." Fairchild defined air warfare as "air operations in which primary reliance for the accomplishment of a broad purpose is placed upon the independent employment of air power."[9] Air warfare did not include immediate support to any type of surface forces. Fairchild was

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[4] Maj Muir S. Fairchild, "Air Power and Air Warfare," lecture, Air Corps Tactical School, Maxwell AFB, AL, 21 Mar 1939, in AFHRA, decimal file no. 248.2020A-1, 2-3.
[5] Air Force Doctrine Document (AFDD) 1, *Air Force Basic Doctrine, Organization, and Command*, 14 October 2011, 11.
[6] Fairchild, "Air Power and Air Warfare," 5.
[7] Fairchild, "Air Power and Air Warfare,"5.
[8] Fairchild, "Air Power and Air Warfare," 3.
[9] Fairchild, "Air Power and Air Warfare," 7.

careful to caveat his lecture by stating air warfare may not solely win the war, but contributed to the overall war effort. He was candid in his remarks insisting ACTS used the air warfare definition based on War Department doctrine for the General Headquarters (GHQ) Air Force and not a definition originating within the ACTS faculty.[10]Air warfare, in the opinion of ACTS, was central to US national strategy.

The Influence of US National Strategy

The Air Force course instructors developed the syllabus based on then current US foreign policy. Their interpretation included themes of both isolation and deterrence. Abundant natural resources and a complacent population protected by two oceans encouraged the federal government to focus on domestic issues, especially during the Great Depression. These same features also provided a deterrent: in a time of crisis, the oceans provided time for American industry to convert raw materials into "the world's largest fighting machine."[11] As a result, the US was satisfied with its status during times of relative peace and practiced economic responsibility by maintaining a small military.[12]

Fairchild used Carl von Clausewitz's definition of war to develop a litmus test to determine US military capability to support US foreign policy. Clausewitz defined war as the extension of politics by other means.[13] Fairchild explained the US entered a war because of policy conflicts with another state.[14] He argued that foreign policy and the armed forces had a symbiotic relationship. The composition of the armed forces depended on the nature of foreign policy; however, those

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[10] Fairchild, "Air Power and Air Warfare," 7.
[11] Maj Muir S. Fairchild, "Strategic Offense and Strategic Defense," lecture, Air Corps Tactical School, Maxwell AFB, AL, 3 Apr 1939, in AFHRA, decimal file no. 248.2020A-6, 8.
[12] Fairchild, "Strategic Offense and Strategic Defense," 8.
[13] Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1989), 87.
[14] Fairchild, "Strategic Offense and Strategic Defense," 2.

same armed forces also influenced ongoing foreign policy.[15] The litmus test resided in the ability of the military to enforce all foreign policies.

Building upon the Clausewitzian definition of war, ACTS viewed modern war as a conflict between states, not merely between armed forces, and interpreted US national military policy as generally offensive or defensive in nature.[16] These two viewpoints align with the modern concept of the strategic level of war. The Air Warfare text defined the strategic offensive as military operations designed to bring pressure to bear against the enemy state. Similarly, the Air Warfare text defined the strategic offensive as military operations designed to prevent an enemy state from exerting pressure on a friendly state.[17] ACTS further interpreted a state could not win a war while on the strategic defensive because states attained policy objectives only through strategic offensive action. The strategic defensive was a short-term solution until a state could shift to the strategic offensive to achieve policy objectives.[18]

The preceding analysis of US foreign policy and national military policy drove ACTS to four conclusions. First, modern war demanded both manpower and industrial capability. In these terms, the US was unrivaled in production capability in the world of 1939 and the US was the supreme military power in the western hemisphere. Second, peacetime acquisitions drove the composition and capability of an air force. Someone had to decide the number and type of aircraft required based on foreign policy.[19] Third, the oceans and the present US military had to provide buffer time for American industry to accelerate to wartime production levels.[20] Fourth, in 1939, the US Armed Forces had two

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[15] Fairchild, "Strategic Offense and Strategic Defense," 6-7.
[16] Fairchild, "Strategic Offense and Strategic Defense," 2.
[17] Fairchild, "Strategic Offense and Strategic Defense," 1. Students were assigned readings from an ACTS publication entitled Air Warfare.
[18] Fairchild, "Strategic Offense and Strategic Defense," 3.
[19] Major Frederick M. Hopkins, "Tactical Offense and Tactical Defense," lecture, Air Corps Tactical School, Maxwell AFB, AL, 31 Mar 1939, in AFHRA, decimal file no. 248.2020A-5, 1.
[20] Fairchild, "Strategic Offense and Strategic Defense," 9.

missions: defend US industry and provide US industry time to build the force.[21] Based on these two missions, the Air Force course argued the US military was incapable of enforcing US foreign policy.

1939 Military Shortfalls

The Air Force course instructors developed two assumptions critical to their analysis of US military shortfalls in 1939. First, US industry was extremely interrelated and interdependent. An adversary only needed to destroy a few key facilities in order to impose severe limitations on US industrial production.[22] Second, left undefended, US industry was vulnerable to air warfare.[23] A crippled US industry dictated a decisive US defeat, since policy required industry to build up the US military after an attack had already occurred. Since most major European air forces already possessed the capability to destroy these targets, US ground and naval forces were impotent to prevent such an attack.[24]

Fairchild maintained that the introduction of airpower shrank the world and reduced the security afforded to the US by its geographic isolation.[25] Commercial airfields materialized on remote islands making it easier to ferry aircraft and supplies across the Atlantic.[26] An adversary could use this island network as an intermediary to deploy bomber aircraft to both Mexico and Canada, weak states unable to stave off an invasion.[27] Long-range bombers supplemented by island airfields usurped the US Naval barrier, the primary means of US defense.[28] The second line of defense, the ground force, was easily bypassed in the same

[21] Fairchild, "Strategic Offense and Strategic Defense," 20.
[22] Fairchild, "Strategic Offense and Strategic Defense," 26.
[23] Fairchild, "Strategic Offense and Strategic Defense," 25.
[24] Fairchild, "Strategic Offense and Strategic Defense," 26.
[25] Fairchild, "Strategic Offense and Strategic Defense," 34.
[26] Fairchild, "Strategic Offense and Strategic Defense," 29.
[27] Fairchild, "Strategic Offense and Strategic Defense," 34.
[28] Fairchild, "Strategic Offense and Strategic Defense," 29.

manner.[29] ACTS perceived that the defense of the nation relied upon the Air Corps.

ACTS believed the Air Corps was the force best positioned to defend the US against an air threat, but did not possess the appropriate aircraft to accomplish the task. Maj Frederick M. Hopkins lectured that the concept of the tactical air defensive was faulty for three reasons. First, bombers were capable of all-weather operations while pursuit aircraft were limited to visual meteorological conditions (VMC), that is, pursuit aircraft required clear skies and daylight to attack enemy aircraft. Second, four engine bombers were faster than single engine fighters. Bombers could simply "out run" their attackers. Third, a complex interrelationship of time, position, and number of targets governed pursuit capabilities.[30] This was the true weakness of air defense. A larger pursuit formation had to intercept a smaller bomber formation with enough time to attack it prior to the bomber formation attacking its target.[31] The three Pursuit groups stationed in the continental US augmented by the six available anti-aircraft artillery (AAA) units were insufficient to protect just the power infrastructure, let alone the entire industrial network.[32] ACTS proposed a radical approach to their defensive strategy in the form of offensive firepower forming the justification and basis of their theory of airpower.

ACTS Theory

The airpower concepts of Italian air theorist Giulio Douhet were the foundational concepts of the airpower theory derived at ACTS. Fairchild credited Douhet as the architect of the strategic air offensive and provided a brief synopsis of Douhet's ideas. He indicated Douhet recognized the tremendous potential for offensive airpower to exert "direct pressure" against an enemy state bypassing the adversary's

[29] Fairchild, "Strategic Offense and Strategic Defense," 25.
[30] Hopkins, "Tactical Offense and Tactical Defense," 15-17.
[31] Hopkins, "Tactical Offense and Tactical Defense," 8-10.
[32] Fairchild, "Strategic Offense and Strategic Defense," 35.

fielded forces. Conversely, Fairchild also stated Douhet believed offensive airpower was an effective tool used to defeat enemy air, land, or sea forces, but this function was better suited for the strategic defensive.[33] Although Fairchild did not quote from Douhet's*Command of the Air* or reveal the source of his information, he described concepts established in this seminal work.[34]

The interpretation of Douhet's concepts differed between the European air powers and ACTS. In Europe, ACTS believed the major air powers accepted Douhet's basic principles as fundamental axioms. Central to these axioms was the concept of assuming a defensive posture with surface forces while conducting an air offensive. Fairchild stated this concept may work under certain conditions, but the US should not accept this posture as general doctrine suitable for all cases of war.[35] Douhet also advocated for the use of poison gas munitions against a wide variety of targets to include population centers.[36] ACTS believed European air powers would bomb population centers with poison gas munitions and feared a similar sentiment could infect the Air Corps.[37]

Instead of focusing on population bombing, ACTS introduced a target set focusing on the National Economic Structure (NES) of the state.[38] The selection of this target set must have come somewhat easily as the US Department of War placed the greatest emphasis upon the fundamental importance of the economic effort for future war.[39] The Air

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[33] Fairchild, "Strategic Offense and Strategic Defense,"5-6.
[34] Giulio Douhet, *The Command of the Air*, ed. Joseph Patrick Harahan and Richard H. Kohn (Tuscaloosa, AL.: University Alabama Press, 2009), 23. On page 23 Douhet states: "it means complete protection of one's own country, the efficient operation of one's army and navy, and peace of mind to live and work in safety." He also states: "to be defeated in the air, on the other hand, is finally to be defeated and to be at the mercy of the enemy, with no chance at all of defending oneself, compelled to accept whatever terms he sees fit to dictate."
[35] Fairchild, "Strategic Offense and Strategic Defense,"6.
[36] Douhet, *The Command of the Air*, 20.
[37] Maj Muir S. Fairchild, "The National Economic Structure," lecture, Air Corps Tactical School, Maxwell AFB, AL, 5 Apr 1939, in AFHRA, decimal file no. 248.2020A-9, 1-2.
[38] Fairchild, "The National Economic Structure," 5.
[39] Fairchild, "The National Economic Structure," 8.

Force course argued against civilian population bombing for three reasons. First, it was inhumane and could have negative consequences with neutral states. Second, evidence from WW I suggested it was extremely difficult to break civilian morale with indiscriminate bombing. Third, rapid overwhelming force was required to be effective.[40] The Air Force course still advocated intense suffering of the civilian population was essential for the collapse of national morale and will.[41] ACTS had in mind another method to make the population suffer.

The National Economic Structure target set underpinned ACTS airpower theory. Modern warfare stressed the economic system of a state making it vulnerable. Fairchild used the example of WW I to support ACTS theory. The battlefields were in the industrial areas. Blockades, in one form or another, brought about the end of the war as the Central Powers could not produce materiel required at the front.[42] Every state inadequately supplied for war and relied on rapid economic expansion to equip the manpower it mobilized.[43] Not only was it more humane and more acceptable to neutral states, NES attack reduced the capacity of a state to make war while at the same time it applied "pressure" to the population with efficiency. Fairchild argued the effects were cumulative and lasting and NES attack exerted the same population "pressure" quicker than previous military offensives accomplished.[44]

The remainder of the Air Force course focused on developing fidelity to the basic airpower theory it set forth. To the modern airman familiar with the current USAF, this fidelity came in the form of the doctrinal mission sets of Strategic Attack, Counterair, Counterland, and Countersea. Descriptions for the current mission sets are found in Air Force Doctrine Document 1-1. The differences between current mission

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[40] Fairchild, "The National Economic Structure," 3-5.
[41] Fairchild, "The National Economic Structure," 6.
[42] Fairchild, "The National Economic Structure," 6.
[43] Fairchild, "The National Economic Structure," 7-9.
[44] Fairchild, "The National Economic Structure," 6.

sets and ACTS mission sets is not germane to this discussion and is merely used as a tool to classify ACTS doctrine in a logical form. Each mission set is described below as viewed by ACTS in 1939.

Strategic Attack

The Air Force course advocated the only path to win any war was through the strategic offensive, and an air force contributed to the war effort in an innovative manner.[45] Air forces could act directly, immediately, and continuously against their ultimate objective.[46] Building on the basic theory of NES attack, Fairchild instructed the official policy of ACTS was to support the collapse of a state's industrial machine as the primary mission of any air force.[47] The advantage of NES attack was the fixed nature of the target set. War machines were mobile, hard to locate, and dispersed. The components of the NES required to build the war machines were fixed, concentrated, and the heart of an adversary's strength. These industrial components were the ideal objectives for an air force.[48] They also required a new approach to war.

Fairchild argued the NES target set was complex and target selection required intensive planning and coordination. A thorough analysis accomplished by economists, statisticians, and technical experts was required to develop an overall target list. Intelligence provided by reconnaissance and other sources played a crucial role to aid in the NES analysis. The ability to develop a thorough intelligence analysis was also unique to the NES as military forces become mobile once hostilities commenced.[49] Thus a war plan attacking fixed targets, such as the NES,

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[45] Fairchild, "Strategic Offense and Strategic Defense,"9.
[46] Maj Muir S. Fairchild, "Primary Strategic Objectives of Air Forces," lecture, Air Corps Tactical School, Maxwell AFB, AL, 11 Apr 1939, in AFHRA, decimal file no. 248.2020A-14, 2-3.
[47] Fairchild, "The National Economic Structure," 10.
[48] Fairchild, "Primary Strategic Objectives of Air Forces," 13-14.
[49] Fairchild, "Primary Strategic Objectives of Air Forces," 7.

could be a detailed and actual plan of operations.[50] A detailed plan would have decisive consequences.

The US industrial machine provided an excellent example for the Air Force course to justify NES attack. Appealing to the students, Fairchild stated that picturing a systematic takedown of the US industrial system lead one to assume an idea of the "pressure" exerted on the US population.[51] The horsepower aiding the American worker made him worth two Frenchmen, nearly two Germans, three Italians, or three-and-a-half Russians.[52] This horsepower took the form of US concentrated industry supported by a robust transportation network, both of which were critical vulnerabilities of the US economic system.[53] An attack on the NES caused a chain-reaction effect crippling the system causing production to stop not only on war-related equipment, but also on goods sustaining the American way of life.[54] Fairchild assumed the effects were nothing short of decisive and translated to any state.[55] The Air Force course attempted to identify the key nodes of the NES whose attack was most decisive.

The first two key nodes the Air Force course considered were the oil and steel industries. The Air Force course eliminated strategic raw materials as a target set because a state imported these materials from a variety of locations.[56] Instead, the focus was on the apparatus tasked with converting raw materials into finished products. As modern society became dependent on petroleum products to fuel its military apparatus and civilian way of life, the oil industry was a logical target set. The refineries were the critical vulnerability of the oil infrastructure making the ideal target set within the oil industry. Within the US, the

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[50] Fairchild, "The National Economic Structure," 10-11.
[51] Fairchild, "The National Economic Structure," 36.
[52] Fairchild, "The National Economic Structure," 15.
[53] Fairchild, "The National Economic Structure," 26.
[54] Fairchild, "The National Economic Structure," 36.
[55] Fairchild, "Primary Strategic Objectives of Air Forces," 14.
[56] Fairchild, "The National Economic Structure," 18.

distribution networks and storage capability made the industry robust and Fairchild concluded it would be difficult to yield decisive results. States without the robust oil industry infrastructure of the US, however, were susceptible to attacks on refineries, and these could be decisive.[57]

The analysis for the steel industry yielded the same recommendations. Steel was required to build a mechanized army, modern air force, and blue water navy. The same steel was required to produce a myriad of civilian products as well. Without steel, the military machine ground to a halt and civilians endured hardship. The steel industry shared some of the same robustness as the oil industry in terms of distribution, but the concentration of the factories in this instance made this industry more vulnerable than the oil industry. Pure conjectures led to an analysis that steel could be decisive; however, Fairchild stressed the fact a detailed analysis of the steel industry was required during peacetime to determine the decisive effects it would have on a state's NES.[58] Neither the oil or steel industries seemed to be decisive by ACTS standards, but these two industries shared the consumption of another, more decisive commodity.

The commercial power industry was the most vulnerable target set which affected every other aspect of a state's NES; without it, the entire industrial machine ceased to produce.[59] Some factories still produced their own power, but central power facilities were quickly becoming the standard for industry. The commercial power industry also supplied the additional power required during a time of state emergency, such as the outbreak of war. As the world emerged from the Great Depression, no state, including the US, possessed an electric power surplus. In-fact, most had a deficiency.[60] In this context, Fairchild stated "it seems

[57] Fairchild, "The National Economic Structure," 20-22.
[58] Fairchild, "The National Economic Structure," 22-24.
[59] Fairchild, "The National Economic Structure," 9.
[60] Fairchild, "The National Economic Structure," 28-29.

certain that it would be sufficient to strain [US power production] to the breaking point, if it did not, indeed, prove to be conclusive."[61]

The commercial power infrastructure was vulnerable to attack for three reasons. First, power transmission was limited by distance, which meant power-producing facilities located more than 300 miles away from a factory could not supply it with electric power.[62] Second, eliminating a single transmission component rendered the entire line inoperable, meaning an attack could focus on a small portion of the transmission line. Third, power-generating turbines were fragile components ACTS determined were vulnerable to the slightest foundation movement caused by detonations. The Air Force course concluded these vulnerabilities meant every mass attack on power infrastructure succeeded in achieving some level of destruction. The Air Force course also concluded the destruction of critical power infrastructure prevented industry from manufacturing for one to two years.[63] Fairchild went as far as to state: "the results would be immediate, cumulative, and comparatively permanent."[64]

The preceding analysis encouraged the ACTS student to ponder multiple ramifications. No two states were equal and therefore some states may not possess a national economic structure critically vulnerable to air warfare. In the case of the Air Corps, it did not possess the required aircraft to accomplish an NES attack, but believed the technology existed and US industry could provide modern aircraft.[65] Most importantly, Fairchild described his analysis as amateurish. He concluded the Air Corps must conduct a thorough analysis of an adversary's economic structure in order to identify the critical vulnerabilities that became the target sets of an air force. Although NES

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[61] Fairchild, "The National Economic Structure," 36.
[62] Fairchild, "The National Economic Structure," 30.
[63] Fairchild, "The National Economic Structure," 32-34.
[64] Fairchild, "The National Economic Structure," 34.
[65] Fairchild, "Strategic Offense and Strategic Defense,"18.

attack was the best use of an air force, ACTS advocated against this strategy when an air force could not accomplish it or when the principle of security demanded an air force for other purposes.[66] Finally, how could the Air Corps prevent a NES attack against the US?[67]

Counterair

The Air Force course acknowledged the Air Corps must address the threat of enemy aircraft to a friendly state's NES and military forces. The initial phase of any enemy offensive would likely be an air offensive directed at the friendly NES. Therefore, ACTS recommended the US establish a robust air force in both North and South America to protect against an enemy air threat.[68] If the US assumed the strategic offensive and decided to use surface forces, ACTS assumed the Air Corps would destroy the enemy air force before implementing a ground offensive.[69] In this capacity, eliminating an enemy air force protected the decisive war-producing machine, secured the surface LOCs, and created a permissive environment for any land and naval forces.[70] The Air Force course explored both defensive and offensive means to accomplish these tasks.

Two philosophies existed within ACTS on the subject of defending against and defeating an enemy air force. The bomber advocates believed bombers were faster than pursuit aircraft and could defend themselves. The bomber was a versatile platform capable of defending against an enemy air force by defeating it while it was on the ground. The pursuit advocates argued the fighter was deadly to a bomber formation. It defended against an enemy air force by defeating it in the air.[71]Instead of developing a synergistic doctrine taking advantage of the

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[66] Fairchild, "The National Economic Structure," 36-37; Fairchild, "Primary Strategic Objectives of Air Forces," 14.
[67] Fairchild, "Primary Strategic Objectives of Air Forces," 4-5.
[68] Fairchild, "Strategic Offense and Strategic Defense,"36-37.
[69] Fairchild, "Strategic Offense and Strategic Defense,"18.
[70] Fairchild, "Primary Strategic Objectives of Air Forces," 6.
[71] Hopkins, "Tactical Offense and Tactical Defense," 2-3.

capabilities of both bomber and pursuit aircraft, the Air Force course highlighted the shortcomings of pursuit.

The Air Force course evaluated the extremes of pursuit tactics and utilized disadvantageous force ratios to discourage students from pursuit advocacy. Pursuit aircraft were day-VMC only aircraft incapable of operating at night or in the weather, two regimes bombers thrived in.[72] Hopkins argued pursuit aircraft were either extremely effective in the case of a heavily defended point target, or they were ineffective in the case of a poorly defended point target.[73] A heavily defended point target was unlikely to be a reality as the US industrial machine was distributed from the Atlantic seaboard to the Great Lakes. Enemy bombers would be faster, in enormous formations, and could strike at unpredictable locations and times. Thousands of aircrew and pursuit aircraft were required to defend US industry. Instead, the Air Force course recommended focusing on developing a bomber-focused air force.[74]

ACTS embraced technology and used it to influence the decision to support the bomber over pursuit aircraft. During the 1930's, the trend in technical development favored bombers and attack aircraft over pursuit aircraft. Since the Air Corps could not contain enemy bombers with pursuit aircraft, it seemed the only method to defend against an air threat was to defeat it at its source.[75] Thus, the best defense became a bitter air offensive against the adversary air force utilizing bomber aircraft.[76] The perception of the Air Force course was the bomber was the primary means of destroying both the NES and an adversary's air force cementing the bomber as the Air Corps ultimate acquisition priority.[77] The multi-role bomber supported other missions as well.

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[72] Hopkins, "Tactical Offense and Tactical Defense," 6.
[73] Hopkins, "Tactical Offense and Tactical Defense," 14.
[74] Hopkins, "Tactical Offense and Tactical Defense," 21.
[75] Hopkins, "Tactical Offense and Tactical Defense," 23.
[76] Hopkins, "Tactical Offense and Tactical Defense," 24; Fairchild, "Strategic Offense and Strategic Defense,"36-37.
[77] Fairchild, "Strategic Offense and Strategic Defense,"18.

Counterland

Airpower and mechanized ground forces in the 1930s evolved quickly, making the modern battlefield unpredictable. The Air Force course argued neither the airman nor the soldier knew best how to incorporate the two, which caused speculation.[78] Airpower increased the depth of the ground commander's theater of operations while mechanized forces moved rapidly making the ground lines of communication (LOCs) vulnerable. These developments forced the ground commander to defend his LOCs with combat troops, limiting the numbers available for the front.[79] The air force commander aided the ground commander by destroying the enemy air force, creating a permissive environment for the ground commander to conduct operations.[80] Other methods existed for the air force commander to support the ground commander.

There were two scenarios when the primary objective of an air force should be to support the ground commander. Both involved decisive situations affecting the overall strategic posture of the state because the consequences of an NES attack had yet to take effect. First, an air force should support a ground commander tasked to accomplish a decisive objective. Second, an air force should support a ground commander in danger of being overrun resulting in a decisive victory for the enemy.[81] Hopkins summarized the infantry-artillery-aviation construct was justified if it was concentrated on the decisive point contributing to an ultimate decision taking advantage of airpower's mobility.[82] These were the only two scenarios when an air force diverted from focusing on NES attack or destroying the enemy air force; however, a small portion of an air force could support the ground commander in other instances.

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[78] Major F.M. Hopkins, "The Influence of Air Power on Land Warfare," lecture, Air Corps Tactical School, Maxwell AFB, AL, 30 Mar 1939, in AFHRA, decimal file no. 248.2020A-12, 1.
[79] Hopkins, "The Influence of Air Power on Land Warfare," 13.
[80] Hopkins, "The Influence of Air Power on Land Warfare," 16-17.
[81] Fairchild, "Primary Strategic Objectives of Air Forces," 8-9.
[82] Hopkins, "The Influence of Air Power on Land Warfare," 4, 11.

ACTS proposed using airpower in an interdiction role to support the ground commander in a limited fashion. Hopkins described four phases of a generic ground campaign as the concentration, advance, battle, and pursuit phases. Airpower could interdict troop and supply movements during any of these phases. During the concentration phase, airpower could attack trains and vehicles transporting troops and supplies to assembly areas. During the advance phase, airpower could attack troops and vehicles advancing from assembly areas towards friendly forces. The phrase "before contact with the enemy" no longer had meaning on the modern battlefield.[83] An air interdiction campaign could weaken ground forces during the advance as they entered the battle phase.

The battle phase presented two options for the use of airpower. During the battle phase, airpower could prevent resupply of enemy forces engaged with friendly forces by attacking enemy LOCs, or it could directly support engaged friendly forces. Hopkins suggested ground commanders did not appreciate the cost of the modern aircraft and recommended airpower attack LOCs instead of directly supporting engaged friendly ground forces. Finally, in the pursuit phase, airpower could attack retiring troop columns preventing escape and reconstitution.[84] The air force commander only apportioned available excess forces for interdiction missions.

The introduction of airpower to the modern battlefield changed the character of the warfare. The Air Force course argued major states would always go to war with large and powerful air forces. Before an army meets an enemy army on the battlefield, ACTS recommends an air force must destroy the enemy air force and weaken the adversary's army through an extensive interdiction campaign. Further, air forces may become the predominant offensive force for states with armies engaged in

[83] Hopkins, "The Influence of Air Power on Land Warfare," 6-7.
[84] Hopkins, "The Influence of Air Power on Land Warfare," 12.

battle against fortified lines such as the Maginot and Siegfried Lines.[85] Airpower influenced naval warfare as well.

Countersea

Naval warfare was rapidly changing in the 1930's, largely due to the introduction of long-range aircraft and the aircraft carrier. Disagreements between the US Navy and the Air Corps led the Air Force course to challenge the Navy as the arbiter of seapower. The Air Corps believed all classes of shipping were vulnerable to bombs while aircraft were invulnerable to antiaircraft artillery. Further, bombs and battleships were incompatible.[86] The Air Force course defined naval warfare as the engagement of opposing battle lines with big guns.[87] An identity crisis was underway in the Navy as the battle for supremacy raged between the aircraft carrier and the battleship. Meanwhile, the Naval War College, won over by the potential of the aircraft, argued the aircraft had changed the character of naval warfare.[88] ACTS proposed airpower had displaced seapower as the superior force on the high seas.

Building on the policies of the Naval War College, the Air Force course surmised naval battles no longer occurred near coastlines. Airpower forced the setting of naval battles from locations serviceable by naval bases to positions beyond the combat radius of land-based air forces. The implication was no fleet could enter hostile waters without air superiority.[89] Sustained operations without the support of naval bases required open sea lines of communication (SLOCs) for tankers, supply ships, and ammunition ships, which were vulnerable to air attack and were possibly vital to success or failure in the naval battle.[90] More

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[85] Hopkins, "The Influence of Air Power on Land Warfare," 17.
[86] Captain Lawrence S. Kuter, "The Influence of Air Power on Naval Warfare," lecture, Air Corps Tactical School, Maxwell AFB, AL, 30 Mar 1939, in AFHRA, decimal file no. 248.2020A-13, 2.
[87] Kuter, "The Influence of Air Power on Naval Warfare," *4.*
[88] Kuter, "The Influence of Air Power on Naval Warfare," 10-11.
[89] Kuter, "The Influence of Air Power on Naval Warfare," 6-7.
[90] Kuter, "The Influence of Air Power on Naval Warfare," *9.*

importantly, SLOCs were vital for merchant vessels supplying the overall war effort.

Seapower's primary purpose was to gain and maintain command of the sea in order to control the SLOCs. Command of the sea enabled a state to protect friendly shipping, deny enemy shipping, escort friendly invading forces, and prohibit adversary forces from invading across the seas.[91] Cargo, merchant, supply or transport ships were all vulnerable to air attack making airpower influential in obtaining command of the sea.[92] Much like supporting frontline troops, bombing battleships was unimportant; other targets were more lucrative and consequential.[93] The Air Force course also recommended interdicting the supply ships supporting the battle lines before a naval engagement occurred.[94] ACTS concluded command of the sea required the defeat of both a fleet and the air force; however, since an air force could destroy merchant shipping alone, the presence of a fleet was inconsequential.[95]

"Since the advent of air power, sea power itself is submerged to total dependence upon air power."[96] Command of the air was required to command the sea. The Air Force course believed airpower was more important than seapower.[97] A fleet required some method of obtaining air superiority in order to project seapower, as air forces were effective against all naval surface vessels.[98] Surprisingly, after sinking the reason for a navy at all, the Air Force course recommended the US was stronger with both the Air Corps and Navy without providing a reason.[99] Perhaps aircraft carriers and submarines deserved to be in the US arsenal after all.

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[91] Kuter, "The Influence of Air Power on Naval Warfare," 14.
[92] Kuter, "The Influence of Air Power on Naval Warfare," 12-14.
[93] Kuter, "The Influence of Air Power on Naval Warfare," *6.*
[94] Kuter, "The Influence of Air Power on Naval Warfare," *10.*
[95] Kuter, "The Influence of Air Power on Naval Warfare," *16.*
[96] Kuter, "The Influence of Air Power on Naval Warfare," *19.*
[97] Kuter, "The Influence of Air Power on Naval Warfare," *16.*
[98] Kuter, "The Influence of Air Power on Naval Warfare," *12.*
[99] Kuter, "The Influence of Air Power on Naval Warfare," *17.*

Conclusion

The Air Force course did not teach tactics, but was the School's attempt to forge a single cohesive airpower theory for the Air Corps. This course separated the Air Corps from the rest of the Army and the Navy. While the Army's primary strategic objective was always the enemy army and the Navy's primary strategic objective was always the enemy navy, the Air Corps was unique. The School insisted the Air Corps' primary objective was the enemy's national economic structure, but it could also be the enemy air force, army, or navy.[100] The Air Corps was also unique in that it was solely capable of protecting the US homeland. ACTS viewed airpower as vital to defending against an enemy air force, preventing enemy army and naval forces from reaching US coastlines, and controlling the sea lines of communication.[101] Finally, the School foreshadowed Cold War theories of deterrence and coercion. Citing the Munich 1938 agreement, both Major Fairchild and Major Hopkins inferred airpower either deterred or coerced western European powers from coming to the aid of Czechoslovakia.[102]

The School believed airpower was flexible and this was both a strength and a weakness. Air forces held a variety of target sets at risk such as airfields, port facilities, troop columns, battleships, rail centers, artillery batteries, factories, bivouacs, bridges, cities, and the infantry line in battle.[103] This versatility provided the state with a powerful weapon, but the danger lay in its misuse. The School believed airpower employment required wider thinking and flexible planning because its mobility enabled it to switch missions more rapidly than the Army or Navy.[104]

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[100] Fairchild, "Primary Strategic Objectives of Air Forces," 3.
[101] Fairchild, "Strategic Offense and Strategic Defense,"37.
[102] Fairchild, "Strategic Offense and Strategic Defense,"30; Hopkins, "The Influence of Air Power on Land Warfare," 3.
[103] Fairchild, "Primary Strategic Objectives of Air Forces," 1.
[104] Hopkins, "The Influence of Air Power on Land Warfare," 17.

Unfortunately, there was no unified opinion among military personnel in general on the proper use of an air force. Soldiers and sailors attempted to pigeonhole air warfare into the old picture of traditional warfare without regard to the proper application of the real historical fundamentals of war.[105] ACTS argued that while flexible, airpower was not efficient as a defensive weapon one day and as an offensive weapon the next in any air situation.[106] WW I did not provide the pioneering airmen such as Douhet with enough evidence to communicate a comprehensive theory of air warfare. Airpower was too young to have its Napoleon, Clausewitz, or Schlieffen. A master strategist, Major Hopkins argued, would have treated airpower as an equal.[107]

The most fundamental decision involved in air warfare was the choice between strategic bombing and counterforce operations.[108] In 1939, the School feared the Air Corps did not possess the aircraft required to accomplish either. Fairchild believed the art of air strategy consisted in a strategic analysis resulting in prioritized objectives that exploited the advantages of airpower securing its maximum contribution to the national strategy.[109] To this end, the School highlighted in the Air Force course the importance of acquiring hundreds of long-range bombers.[110] These aircraft were the salvation for the School's maxims. First, the least vulnerable state would attack the national structure. Second, the most vulnerable state would attack the enemy air force. Finally, the initial attacks of any aggressor are against the national structure for shock effect.[111] These maxims and a desire for aircraft played out in the Bombardment and Attack courses. The Bombardment

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[105] Fairchild, "Primary Strategic Objectives of Air Forces," 2.
[106] Hopkins, "The Influence of Air Power on Land Warfare," 2.
[107] Hopkins, "The Influence of Air Power on Land Warfare," 18.
[108] Fairchild, "Primary Strategic Objectives of Air Forces," 4.
[109] Fairchild, "Primary Strategic Objectives of Air Forces," 5.
[110] Fairchild, "Strategic Offense and Strategic Defense,"19.
[111] Fairchild, "Primary Strategic Objectives of Air Forces," 7.

section explored methods to affect a national structure with the big bomber already in existence, the B-17. Meanwhile the Attack section explored methods of counterforce warfare and searched for an identity, without the support of an ideal aircraft. The themes, struggles, and recommendations of these two courses laid the foundation for American aerial participation in World War II.

Chapter 2

The Bombardment Course

We shall see that only bombardment aviation has the power to destroy all surface material objectives vital to the enemy.

Captain Ralph A. Snavely

The culture nurtured at the Air Corps Tactical School during the 1930s showed up most clearly in the Bombardment course. The Bombardment course consisted of 42 hours of instruction including lectures, two bombing probability problems, a bombing probability quiz, six illustrative problems, three map problems, and one general quiz.[1] The course began in late January 1939 after the Pursuit and Observation courses finished, as the Attack course neared completion, and concluded in late March, just before the Air Force course began.[2] The ACTS faculty stressed bombardment aviation was emerging from its embryonic stage. Captain Ralph Snavely suggested airmen presently dedicated more scholarship and thought to the development of bomber employment than at any other time in the history of military aviation.[3]

The purpose of the Bombardment course was to prepare the student for group command by positioning him on a group staff who explored the mission, capabilities and limitations, and tactics and techniques used to employ the bomber.[4] The scope of the course was limited to placing bombs on target and focused on the tactical level of war from the bomb group down to the individual bomber.[5] ACTS developed a basic course textbook titled "Bombardment", dated 1

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[1] Capt Ralph A. Snavely, "Orientation – Bombardment Aviation" lecture, Air Corps Tactical School, Maxwell AFB, AL, 30 January 1939, in AFHRA, decimal file no. 248.2208A-1, 14; ACTS, "Form 1" for the "Bombardment" course, 1938-1939, in AFHRA, decimal file no. 248.2208A.
[2] Snavely, "Orientation – Bombardment Aviation," 1.
[3] Snavely, "Orientation – Bombardment Aviation," 3.
[4] Snavely, "Orientation – Bombardment Aviation," 3.
[5] Snavely, "Orientation – Bombardment Aviation," 7-8.

January 1938, focusing on the general tactical principles of bomber employment. Both the Bombardment Section and the bomb groups in the GHQ Air Force used this influential manual.[6] ACTS acknowledged the faculty developed the syllabus based on the ideas discussed in previous years at the School. A humble faculty realized their experience was dated and the experience level of the student body could provide invaluable insight for updating their course material.[7]

The Bombardment instructors presented the course in three sections. The first section introduced the student to bombardment aviation. The second section focused on capabilities and limitations of both the weapons and the aircraft while introducing bombing probabilities to the student. The final section focused on the tactics and techniques utilized to put bombs on target. Instructors believed bombardment aviation was fundamentally different from pursuit, attack, and observation aviation, so the non-bomber aircrew student required an orientation.

Bombardment Course Part 1: Introduction to Bombardment Aviation

The bombardment course referenced both the "Bombardment" text and Training Regulation 440-15 to define bombardment aviation as the component of an air force organized, trained, and equipped to destroy material objectives. Snavely widened the definition to include *any* surface material objective.[8] Bombardment's task was unlimited in scope in that the bomber served as the long-range strike component of an air force.[9] This feature enabled bombers to conduct Counterair missions against enemy air forces based outside the radius of attack aviation, the component usually tasked against this mission.[10] Snavely also

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[6] Snavely, "Orientation – Bombardment Aviation," 8.
[7] Snavely, "Orientation – Bombardment Aviation," 4-5.
[8] Snavely, "Orientation – Bombardment Aviation," 6-7.
[9] Snavely, "Orientation – Bombardment Aviation," 14-15.
[10] Snavely, "Orientation – Bombardment Aviation," 14.

suggested bombers conducted reconnaissance when observation aircraft were unavailable or unable to conduct the mission.[11] Finally, bombers could self-escort when pursuit assets were unable to escort the bombers deep into enemy territory.[12] The bomber was flexible and unafraid, but ACTS also acknowledged the synergistic effects of aircraft packages.

Different aircraft types, when packaged together to accomplish a common mission, constituted a formidable team. Each type of non-bomber aircraft supported the bomber in a different fashion, which Snavely likened to the offensive squad of a football team. Pursuit aircraft protected the bombers against adversary pursuit by running interference and blocking like linemen. Similarly, attack aircraft blocked by destroying or neutralizing hostile antiaircraft artillery (AAA). Observation aircraft served as the fullback. After the air force commander hiked the ball to the bombers, observation aircraft updated target information, marked the route, and illuminated the objective, leading the bombers into the end zone.[13] A successful team is part of a larger successful organization.

The Air Corps faced two fundamental challenges in both organizing and equipping the bomber force. First, no regulation standardized bomb group organization across the Air Corps, indicating both the Air Corps and ACTS were fumbling through a process to find a suitable standard.[14] Second, the entire bomber force consisted of only three groups, further exacerbating the problem.[15] The large bomber forces utilized in the illustrative problems and map problems in the Bombardment course did not exist in the Air Corps, but did exist in air forces of contemporary powers. Snavely used the Italian Air Force as an example to demonstrate both the size and organization of an existing force required to complete

[11] Snavely, "Orientation – Bombardment Aviation," 15.
[12] Snavely, "Orientation – Bombardment Aviation," 2-3.
[13] Snavely, "Orientation – Bombardment Aviation," 1-2.
[14] Capt Ralph A. Snavely, "Organization and Training" lecture, Air Corps Tactical School, Maxwell AFB, AL, 1 February 1939, in AFHRA, decimal file no. 248.2208A-2, 2.
[15] Snavely, "Orientation – Bombardment Aviation," 3B.

the planning exercises presented in the course.[16] He also suggested the existing Air Corps was a feeble force when viewed through the lens of European states faced with imminent air warfare.[17] Regardless of the current situation, the instructors needed some organizational structure in order to effectively plan.

ACTS simplified its organizational problem by focusing on the group level down to the individual bomber. An Air Corps group differed from traditional Army organization because it incorporated portions from three echelons (combat, command, and service) into a hybrid unit.[18] The group was the largest aircraft unit over which a single officer exercised general control. The group commander directed target, route, and formation selection. The faculty recommended a group commander could control four squadrons of nine to ten aircraft each.[19] Unfortunately, a full-strength bombardment group did not exist in 1939 because of a shortage of properly trained aircrew.[20]

The bomb squadron was the foundational unit of a bomb group. A squadron was the largest aircraft unit over which a single officer exercised precise control. Unlike a group commander, a squadron commander was in a position to direct between nine to thirteen individual aircraft in a formation.[21] The squadron commander divided the squadron into three or four flights for administrative purposes. Flight commanders were only responsible for the training, instruction, and inspection of assigned aircrew.[22] ACTS faculty stressed the importance of this position as effective weapons delivery depended on the

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[16] Snavely, "Organization and Training," 16.
[17] Snavely, "Organization and Training," 17.
[18] Snavely, "Organization and Training," 4.
[19] Snavely, "Organization and Training," 6-7. The three bombers ACTS used were the B-10, B-17, and B-18. ACTS acknowledged controlling a B-17 group may be different than controlling a B-10 group, but data and experience did not exist to distinguish the two.
[20] Snavely, "Organization and Training," 16.
[21] Snavely, "Organization and Training," 6.
[22] Snavely, "Organization and Training," 8.

coordinated efforts of all members of the combat crew.[23] The composition of the combat crew was still a nebulous concept.

Large, complex bombers capable of long-range missions drove the Air Corps to reconsider the duties of individual aircrew members. The obsolete B-10 combat crew consisted of a pilot-commander, a navigator-bombardier-gunner, a copilot-gunner, and a radio operator-gunner.[24] The B-17 and B-18 eliminated some of the multirole crew positions by incorporating an aircrew composed of a commander, a pilot, a copilot, a bombardier, a navigator, a radio operator, and gunners. The B-17 added an engineer as well. The number of combat crews required for each four-engine bomber was still undetermined.[25] Perhaps even more unsettling, the required rank of individual aircrew members was still unresolved.[26]

The ACTS faculty attempted to provide recommendations for individual aircrew rank based on command functions, but struggled with certain positions. The easiest positions were the commander, pilot, and the gunners. Both the commander and the pilot needed to be officers, but Snavely failed to mention anything about the copilot.[27] Gunners did not need to be officers, but they needed to be non-commissioned officers worthy of the title: "dead eye dick with the aerial machine gun."[28] The tough positions were the bombardier, navigator, and engineer. None of these positions required leadership qualities, but did require a high level of initiative, intelligence, judgment, and common sense. Snavely recommended these aircrew positions may need to be carefully selected officers, but did not make a definitive recommendation.[29] Regardless of rank, every aircrew member needed to understand the awesome power of the demolition bomb and its weaknesses.

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[23] Snavely, "Organization and Training," 15.
[24] Snavely, "Organization and Training," 8.
[25] Snavely, "Organization and Training," 9.
[26] Snavely, "Organization and Training," 9.
[27] Snavely, "Organization and Training," 10.
[28] Snavely, "Organization and Training," 11.
[29] Snavely, "Organization and Training," 12.

Bombardment Course Part 2: Capabilities and Limitations

To plan an air campaign effectively, planners must understand the capabilities and limitations of the tools of air warfare. In the opinion of ACTS instructors, the bomber was the definitive platform in flexibility because of its range and ability to carry different weapons.[30] The Bombardment section designed the capabilities and limitations portion of the course to prepare the planner and provide the group commander an appreciation for mission complexity when it came time to make the difficult decisions.[31] The Bombardment section accomplished this daunting task by first describing the bombers and the weapons. The true contribution to wartime planning came in the form of ACTS' innovative method of determining bombing probabilities, a mathematical tool developed to determine how many bombs were required to destroy a target. The bombers were getting bigger, faster, and more complex.

The Aircraft

The Air Corps was in the midst of a major transformation in 1939. The technological revolution soared as the four-engine bomber relegated the older two-engine bombers to obsolescence; however, few existed and the Air Corps was still in the learning phase. The majority of the bombers in the inventory were two-engine B-10s and B-18s, complemented by a handful of four-engine B-17s. ACTS provided a quick overview of these aircraft, but avoided specific details.[32] Instead of focusing on current aircraft capabilities, the Bombardment course focused on capability requirements based on the perceived limitations of the aging B-10.

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[30] 1st Lieutenant Leonard F. Harman, "The Bombardment Airplane" lecture, Air Corps Tactical School, Maxwell AFB, AL, 6 February 1939, in AFHRA, decimal file no. 248.2208A-5, 4.
[31] Capt Lawrence S. Kuter, "Practical Bombing Probabilities" lecture, Air Corps Tactical School, Maxwell AFB, AL, 7 February 1939, in AFHRA, decimal file no. 248.2208A-7 Part 1, 10.
[32] Harman, "The Bombardment Airplane," 12-15.

The limiting range factor for any bomber is its maximum gross weight. A heavy fuel load increased the range of the bomber, but limited the bomb load. Similarly, a heavy bomb load decreased the range since the bomber carried less fuel. The Bombardment course instructed planners to factor the careful balance between fuel and bomb load in with other tactical planning considerations. From an acquisition perspective, ACTS instructors advocated bombers must be able to reinforce one US coast from the other in a single sortie, which drove a range requirement.[33] Other gear on the bomber added to the maximum gross weight, further reducing the range of the aircraft.

A bomber was a complex aircraft requiring a variety of equipment to accomplish its mission. Flight instruments were required to fly through clouds and maintain altitude, advanced navigation instruments were required to find the target area after flying for thousands of miles, and communication equipment was required for crew coordination and formation integrity. Bomb racks mated bomber to bombs while the bombsight enabled the bomber to identify the target. Finally, a bomber needed machine guns for self-defense.[34] The Air Corps struggled with the rapid pace of technological development forcing replacement of tactically obsolete aircraft which were still structurally and mechanically viable.[35] Always wanting the best equipment industry could produce, ACTS suggested the Air Corps prioritize advanced engines, instruments, and soundproofed crew compartments providing heat and ventilation.[36] ACTS wanted to minimize the discomfort of a long, cold sortie so the bombardier could effectively operate his clandestine equipment.

The only piece of equipment the Bombardment course covered in detail was the Norden bombsight. ACTS acknowledged two different bombsights existed, but failed to compare and contrast the two because

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[33] Harman, "The Bombardment Airplane," 2-3.
[34] Harman, "The Bombardment Airplane," 5.
[35] Harman, "The Bombardment Airplane," 6.
[36] Harman, "The Bombardment Airplane," 5.

it was beyond the scope of the course for two reasons.[37] First, the Norden bombsight, the most sophisticated and secret piece of military hardware in the 1930s, was an analog computer that used mechanical gears to solve multiple mathematical equations providing a bombing solution.[38] Second, ACTS courseware was typically unclassified, including the lecture that discussed bombsights, but the discussions sometimes elevated to classified levels. In the case of the bombsight, the instructor made a note to discuss the "secret nature" of the bombsight, and probably focused on a very general description as the only airmen in the Air Corps who really needed in-depth knowledge of the bombsight were the bombardiers.[39] Instead, ACTS focused on how the bombsight made the bomber a potent weapon.

By 1939 standards, the bombsight transformed an erratic aircraft into a precise bomb-dropping machine. Norden gyroscopically stabilized the bombsight in both azimuth and elevation. The addition of stabilized bombing approach equipment (SBAE) enabled the bombsight to act as an autopilot, stabilizing the entire aircraft. The bombardier inputted altitude, speed, and weapon ballistic data to calibrate the bombsight. During the bomb run, the bombardier placed the cross hairs on a target index to solve for both the drift angle and range angle. The Norden bombsight computed a solution and, through the SBAE, guided the bomber to a bomb release line.[40] ACTS touted the accuracy of the Norden bombsight by citing the statement of one bombardment squadron commander who believed 16 of his 17 bombardiers could place half of

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[37] Harman, "The Bombardment Airplane," 8-9. Harman's lecture never referred to the bombsight by the name "Norden" or its military designation. The author inferred he was describing the Norden bombsight because of his reference to the US Navy.
[38] Stephen L. McFarland, *America's Pursuit of Precision Bombing, 1910-1945* (Washington: Smithsonian, 1995), 73, 75, 154-155. McFarland provides excellent examples of the security measures the Air Corps exercised in order to guard the bombsight. These measures included procedures for bombardiers as well as maintenance and logistics personnel who handled the bombsight.
[39] Harman, "The Bombardment Airplane," 8.
[40] Harman, "The Bombardment Airplane," 10.

their bombs within a 100-foot radius of the target from 20,000 feet.[41] This was a bold statement considering a 2012 B-52 equipped with a flight computer and radar produces inferior results.[42] The technological innovations of the 1930s encouraged the Air Corps to believe it was possible to build a bomber with the same prestige as a Navy battleship.

In a time when four-engine propeller driven bombers just began to fly, ACTS accurately predicted future USAF bombers would be a tool of national policy.[43] The Bombardment course introduced the term "Capital Bomber" as a superior bomber capable of providing strategic defense for the United States. ACTS compared "Capital Bomber" production to Capital Ship production. A Capital Bomber, manufactured on a production line, was quicker to produce than a Capital Ship and easier to replace than a Capital Ship.[44] ACTS envisioned a time when "Capital Bombers" would be the focus of international arms conferences eventually embodied by the Strategic Arms Limitation Treaty and Strategic Arms Reduction Treaty.[45]

The Weapons

Unlike modern USAF bombers capable of carrying a variety of different munitions, the Air Corps bombers of the 1930's primarily carried a single type of munition, the high explosive demolition bomb, even though other munitions existed.[46] The "Bombardment" text classified munitions by three classes, further subdivided into five groupings; however, the ACTS instructors failed to describe each class.[47] They displayed interest in torpedoes, chemical bombs, and incendiary

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[41] Harman, "The Bombardment Airplane," 9.
[42] Author's personal experience.
[43] Harman, "The Bombardment Airplane," 16.
[44] Harman, "The Bombardment Airplane," 17-18.
[45] Harman, "The Bombardment Airplane," 18.
[46] Capt Lawrence S. Kuter, "The Power and Effect of the Demolition Bomb" lecture, Air Corps Tactical School, Maxwell AFB, AL, 3 February 1939, in AFHRA, decimal file no. 248.2208A-3, 1.
[47] Capt Ralph A. Snavely, "Methods of Bombing" lecture, Air Corps Tactical School, Maxwell AFB, AL, 7 February 1939, in AFHRA, decimal file no. 248.2208A-6, 2.

bombs, but weapon characteristics posed issues. The bombers physically could not carry torpedoes, a suitable alternative for low altitude operations against naval targets when weather prevented high altitude attacks.[48] Contemporary chemical bombs utilized mustard gas and only weighed 30 pounds, which the faculty argued was a waste of a bomb bay.[49] Incendiary bombs utilized thermite, but failed to produce the fires demolition bombs produced.[50] Fragmentation bombs also seemed to be available, but the Bombardment instructors failed to discuss them in detail.[51] The limitations of the general-purpose demolition bombs were minuscule compared to the restrictions of the specialized weapons.

Poor design discipline contributed to the weight limitations demolition bombs imposed on the bombers. The Air Corps demolition bomb arsenal consisted of 100, 300, 600, 1,100, and 2,000-pound munitions. The 100-pound bomb originated from WW I while the Air Corps developed the remaining four during the interwar period. Snavely suggested the original design specifications for the medium weight bombs were 250, 500, and 1,000 pounds. Unfortunately, the prototypes weighed 300, 600, and 1,100 pounds and the Air Corps did not elect to force a redesign process. Instead, the Air Corps populated the arsenal with heavier bombs that produced the same effects as their lighter design counterparts. The result was a weight penalty on the bomber forcing a lighter fuel load, decreasing the bomber's overall range.[52] A bomber

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[48] Snavely, "Methods of Bombing," 8.
[49] Snavely, "Methods of Bombing," 2-4. Three projects were underway to develop chemical bombs for bombers. First, a thin-walled stabilized chemical bomb based on the 100lb demolition bomb. Second, an un-stabilized thin-walled container commonly referred to as a tin can. Third, a spray system incorporated into the bomber.
[50] Kuter, "The Power and Effect of the Demolition Bomb," 11-12. Kuter described a test at Aberdeen in 1926 where aircraft bombed a pile of railroad ties with thermite bombs, but failed to ignite them. A follow-on demolition bomb test did ignite the railroad ties.
[51] Kuter, "The Power and Effect of the Demolition Bomb," 8.
[52] Snavely, "Methods of Bombing," 4-5.

carried less than ACTS wanted, but carriage mattered little if the bombs failed to detonate.

A demolition bomb required a fuze to initiate the explosive train. The Air Corps utilized both instantaneous and delay fuzes in demolition bombs. An instantaneous fuze initiated bomb detonation upon impact while a delay fuze initiated bomb detonation a set time after impact. The Bombardment course described three fuze limitations. First, a bombardier could not change the fuze settings while airborne, limiting the ability to strike secondary targets that required a different fuze setting from the originally planned mission. Second, low altitude operations were restricted to above 2,000 feet because a bomber could not attain a safe separation distance from the effects of the bombs it just dropped. Third, long, irregular delays of up to 24 hours were unavailable, limiting the ability to hold an objective area at risk for an extended time.[53] Armed with a basic understanding of bombs and fuzes, the ACTS student was prepared to explore the basics of bombing.

Present-day weaponeering began with the rudimentary target analysis conducted at ACTS. Weaponeering is a process in which the analysis of a target leads to a solution comprised of weapon/fuze type, impact points, and impact conditions. The Bombardment course described three demolition bomb concepts forming the basis of their weaponeering. First, demolition bombs were capable of destroying or neutralizing any physical target on or under the land and water surfaces of the earth. Capt Lawrence Kuter acknowledged this was theoretically possible, but unproven in all cases. Second, each target required the use of the appropriate size bomb. A smaller number of larger bombs reduced the bombing probability, discussed in the next section. Finally, each target required specific aim points to achieve the required level of

[53] Snavely, "Methods of Bombing," 7-8.

damage.[54] The sole impact condition ACTS considered was the effect release altitude imposed on impact velocity.[55] Target types drove weaponeering considerations.

ACTS divided targets into two categories. Anchored targets attached to the Earth's surface consisted of industrial buildings, bridges, docks, and heavy naval vessels. Unanchored targets rested on the Earth's surface and included grounded aircraft, ammunition dumps, locomotives, rolling stock, and train tracks.[56] Kuter recommended using delay fuzes against anchored targets and instantaneous fuzes against unanchored targets. Delay fuzed weapons penetrated the surface and created a "tamping" effect designed to uproot anchored targets.[57] Nothing illustrated the "tamping" effect better than the remnants of a strategic target; unfortunately, there were limited examples.

ACTS was frustrated with the limited bomb validation data existing in 1939. US observers in Spain and China were not experienced bombardment airmen and thus failed to examine and provide detailed reports of bomb damage.[58] Fortunately, a British Royal Air Force (RAF) observation team in Spain reported that bomb damage coincided with RAF technical predictions and WW I historical data. Lacking any other reliable data, Kuter believed WW I data was not obsolete and was consistent with results coming from then current conflicts.[59] This connection was vital for ACTS to legitimize the claim that the Air Corps' primary job was to bomb.[60] Kuter spent two hours defending the power

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[54] Kuter, "The Power and Effect of the Demolition Bomb," 4-5.
[55] Kuter, "The Power and Effect of the Demolition Bomb," 18. Bombs released from higher altitudes impacted targets at a higher velocity allowing for deeper penetration if fuzed with a delay fuze.
[56] Kuter, "The Power and Effect of the Demolition Bomb," 18.
[57] Kuter, "The Power and Effect of the Demolition Bomb," 18.
[58] Kuter, "The Power and Effect of the Demolition Bomb," 14.
[59] Kuter, "The Power and Effect of the Demolition Bomb," 16.
[60] Kuter, "The Power and Effect of the Demolition Bomb," 40.

of the bomb by analyzing bomb damage spanning the short history of bombardment aviation and predicting future results.[61]

The Bombardment course categorized buildings as residential or industrial and used WW I London as an example to provide irrefutable proof of the 100-pound demolition bomb's capability.[62] He dismissed small domestic buildings since (unsurprisingly) the results offered conclusive evidence a direct hit collapsed this type of structure while a detonation in the vicinity caused extensive damage. ACTS considered industrial buildings as standard bombardment targets and included hangars, warehouses, power plants, steel mills, refineries, and aircraft and engine factories. Engineers designed these buildings to withstand substantial floor loadings and the constant shock of heavy machinery. A bombed-out factory illustrated the blast effect of a delay-fuzed bomb in a confined space, the building's sublevels, destroying the support structure, weakening the building, and rendering it unusable.[63] This image stood in stark contrast to a still functioning factory that absorbed the limited damage created by an instantaneous-fuzed weapon detonating on the roof.[64] The cumulative effects of a well-placed bomb in a building did not translate well to targets in the open.

Unanchored targets presented a challenge to the efficacy of the demolition bomb. The blast effect, so conveniently harnessed in a confined space, dissipated rapidly in the open. The bombardment course advocated the demolition bomb was an inefficient munition to use against aircraft, supply and ammunition dumps, and personnel because of the blast dissipation. A demolition bomb destroyed these targets with a direct hit, but the effects were negligible outside of 100 feet. Aircraft and personnel were more susceptible to the fragmentation of the bomb case than the blast effect, leading Kuter to recommend fragmentation

[61] Kuter, "The Power and Effect of the Demolition Bomb," 6.
[62] Kuter, "The Power and Effect of the Demolition Bomb," 11.
[63] Kuter, "The Power and Effect of the Demolition Bomb," 9-10.
[64] Kuter, "The Power and Effect of the Demolition Bomb," 11.

bombs as more efficient against these target types.[65] To highlight this point, Kuter described the effect of a bomb fragment that caused a fire on a loaded B-10 in China, resulting in an explosion destroying the bomber and destroying four others otherwise unscathed by the bombing raid.[66] The chain reaction effect, which worked so well against the bombers, was inconsequential for supply and ammunition dumps spanning multiple acres.[67] An adversary had a difficult time stockpiling supplies if their primary mode of transportation ceased to exist.

ACTS turned to the US Army Ordnance Department and the use of surrogates to weaponeer rail targets. A common practice amongst weaponeers is to use a surrogate when data on a specific target does not exist. Lacking data on a locomotive, Kuter surrogated it with data for the British Mark V tank and assumed the tank was more resilient than the locomotive. The data suggested the blast effect of a 100-pound bomb originating five feet away destroyed these tanks. Using this data and deducing for surrogate differences, ACTS recommended a 100-pound demolition bomb detonating within seven to ten feet of a locomotive would destroy it and rationalized the same solution applied to other rolling stock. Results of an Ordnance Department study recommended utilizing a large number of 100-pound demolition bombs to destroy railroad tracks.[68] Railroad tracks were easy to repair, unless they plummeted into a fast moving river.

A condemned bridge supplied the Air Corps with valuable data used to develop bridge weaponeering solutions. The Pee Dee River Bridge was a reinforced concrete highway bridge supported entirely by concrete piers without suspension. Worried about damaging the replacement bridge standing nearby, the Air Corps bombed the old bridge with inert

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[65] Kuter, "The Power and Effect of the Demolition Bomb," 7-8. A soldier survived a 2000-pound detonation from 100 feet. He escaped the limited fragmentation spent from a demolition bomb.
[66] Kuter, "The Power and Effect of the Demolition Bomb," 15.
[67] Kuter, "The Power and Effect of the Demolition Bomb," 19.
[68] Kuter, "The Power and Effect of the Demolition Bomb," 21-22.

devices, removed them, and statically detonated demolition bombs in their place.[69] Unfortunately, a 600-pound delay-fuzed bomb had a negligible effect against a main pier, but a 1,100-pound delay-fuzed bomb in the same relative location considerably shifted a main pier, causing two approach spans and one main span to collapse. A recurring theme from the factory roof example occurred when a 600-pound instantaneous-fuzed bomb detonated on the bride road, causing insignificant damage.[70] Kuter augmented the Pee Dee River Bridge test using the USS *Virginia* as a surrogate to estimate the damage caused to steel suspension bridges. Using an engineering formula to extrapolate data, Kuter argued a 2,000-pound bomb could cut the heavy steel girders of the San Francisco Bay Bridge in the same way a 1,100-pound demolition bomb mangled the USS *Virginia*, discussed later in this section.[71] Rivers presented an obstacle to transportation, but provided a vital industrial commodity.

Hydroelectric dams generated electric power, making them prime bombardment targets. The Bombardment course categorized dams as either massive, such as the Martin Dam, or "super colossal," epitomized by the Hoover Dam.[72] ACTS maintained that massive dams were vulnerable because the design safety factor did not account for the massive pressure created by a 2,000-pound delay-fuzed bomb detonating within 15 feet of the dam, but the demolition bomb had met its match in the "super colossal" dam.[73] According to Kuter, who previously stated the demolition bomb could destroy any physical target, the "super colossal" dam was impregnable to demolition bombs because engineers designed it to support 600 feet of concrete weight, which allowed the dam

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[69] Kuter, "The Power and Effect of the Demolition Bomb," 24
[70] Kuter, "The Power and Effect of the Demolition Bomb," 25-26.
[71] Kuter, "The Power and Effect of the Demolition Bomb," 27-28. Kuter also stated a 2,000-pound delay-fuzed demolition bomb detonating at the base of the suspension cables may cut them.
[72] Kuter, "The Power and Effect of the Demolition Bomb," 28-29.
[73] Kuter, "The Power and Effect of the Demolition Bomb," 28.

to withstand water pressure considerably higher than actually required.[74] The "super colossal" dam; however, was worth less without the ability to generate power.

A good weaponeer analyzes the entire target complex to find the weaknesses. In the case of either type of dam, the generators and the transformers were the vulnerable spots. The Hoover Dam power generation facility presented an almost bombproof structure designed to protect against rock falls. The roof consisted of eight layers, two layers of reinforced concrete, one of asphalt paving, eighteen inches of cork, six feet of sand and gravel, and top soil with grass. Kuter referenced a Chief of Ordnance official report stating a 600-pound delay-fuzed demolition bomb should penetrate into the actual facility.[75] What Kuter did not realize is that he described a well-designed bunker, a target the USAF continues to explore. Kuter concluded the dam problem by analyzing the transformers. His research showed merely knocking over a transformer destroyed it.[76] The bombardment course finished its journey where it truly began for the Air Corps, off the coast of Virginia.

ACTS claimed that demolition bombs, properly placed, were capable of destroying or neutralizing any naval vessel. A politically unstable environment persisted as Kuter qualified the level of destruction required. Where Mitchell used the term "sink", the approved 1939 ACTS terminology was "effect a material reduction in the combat effectiveness or navigation efficiency, or both."[77] Kuter hinted both the Air Corps and Navy agreed that direct or close along-side hits by 300-pound demolition bombs rendered submarines and destroyers combat ineffective. Kuter displayed pictures of damaged vessels to demonstrate the effectiveness of the 300-pound demolition bomb against light vessels, such as

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[74] Kuter, "The Power and Effect of the Demolition Bomb," 29.
[75] Kuter, "The Power and Effect of the Demolition Bomb," 30.
[76] Kuter, "The Power and Effect of the Demolition Bomb," 30. At the time, transformers were not stored requiring industry to manufacture new ones.
[77] Kuter, "The Power and Effect of the Demolition Bomb," 32. Kuter referred to Mitchell as General Mitchell.

commercial freighters, liners, supply ships, and troop transports.[78] As impressive as these pictures were, the shots across the bow were the capital ships with their big guns.

The Bombardment course proudly displayed the devastated battleships bombed by the pioneers in 1921. Kuter presented pictures of the battleships *Indiana*, *Alabama*, *New Jersey*, and *Virginia* crippled by 300-pound delay-fuzed demolition bombs and argued they were no longer combat effective.[79] He also exhibited pictures after the Air Service dropped 1,100-pound and 2,000-pound demolition bombs on the battleships and recommended either munition were capable of sinking a battleship.[80] Kuter finished by displaying pictures and describing the *Ostfriesland* timeline. This was the only modern battleship with double hulls and bulkheads the Air Service bombed. His timeline stated it only took 18 minutes to sink the ship. It appears Kuter stated one 2000-pound bomb delay-fuzed bomb hit or grazed the *Ostfriesland* and then another one struck within the 35-45 foot effective zone around the ship causing it to sink.[81] None of the proceeding discussion mattered, however, if the required number of bombs failed to make it to the target.

Bombing Probabilities

The Air Corps desired a tool to enable mission planners to determine the number of demolition bombs required to attack specific targets. Charged with this colossal task in the late 1920's, ACTS developed the practical bombing probabilities method.[82] The Law of Errors (LOE) was the mathematical basis for ACTS bombing probabilities. An appendix in the Bombardment Text, the only book in the world addressing the subject in 1939 according to Kuter, described

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[78] Kuter, "The Power and Effect of the Demolition Bomb," 32-33.
[79] Kuter, "The Power and Effect of the Demolition Bomb," 35-37.
[80] Kuter, "The Power and Effect of the Demolition Bomb," 36-37. The *New Jersey*, with four-inch deck armor served as the baseline.
[81] Kuter, "The Power and Effect of the Demolition Bomb," 39.
[82] Kuter, "Practical Bombing Probabilities," 1-2.

the process of applying the LOE to bombing probabilities.[83] The Ordnance Department had examined ACTS mathematical theory and certified it as mathematically sound, adding credence to the method.[84] With a decade of experience and external approval, ACTS decided the theory was mature enough and switched from focusing on the theory to what the students needed, practical application.[85]

Before the students dove into bombing probabilities, they needed to understand the target concept. All targets were classified as either precision or area targets. A precision target required a hit in one precise location while an area target had many points on which bombs could hit and cause some of the desired destruction.[86] ACTS used the terms objective, precision target, and area target in the same manner the modern USAF uses target complex, desired point of impact (DPI), and desired mean point of impact (DMPI). The objective was a target complex consisting of multiple DPIs (precision targets) or DMPIs (area targets).[87] Targets were relatively small from altitude and required a large number of bombs to ensure some bombs would hit the target; thus the requirement for bombing probabilities.[88]

Bombing probabilities were complex, driving ACTS to incorporate a number of assumptions to simplify the process. The Bombardment section assumed the required number of hits was determined by a higher headquarters than the bomb group.[89] ACTS knew variations in altitude, aircraft, bombsights, weather, and proficiency affected bombing probabilities; however, the only measurable variable was altitude.[90] The Bombardment section assumed solving the bombing probability for a 90

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[83] Kuter, "Practical Bombing Probabilities," 6-7.
[84] Kuter, "Practical Bombing Probabilities," 7.
[85] Kuter, "Practical Bombing Probabilities," 7.
[86] Snavely, "Methods of Bombing," 8-9.
[87] Kuter, "Practical Bombing Probabilities," 3-4.
[88] Kuter, "Practical Bombing Probabilities," 5.
[89] Kuter, "Practical Bombing Probabilities," 11. The USAF currently uses a probability of damage assigned by a numbered air force's air operations center.
[90] Kuter, "Practical Bombing Probabilities," 9.

percent possibility of a hit was a sufficient planning standard.[91] The standard for bombing accuracy was the center of the target.[92] Attack azimuth was inconsequential to bombing probabilities because ACTS assumed range and direction errors were equal. Kuter also assumed large formation releases formed a circular pattern invalidating the azimuth error as well.[93]

The bombing probability method did incorporate an error to compensate for overall inaccuracy of the bomber and the demolition bomb. The mean probable error was the measure of bombing accuracy defined as the error a bomb was unlikely to exceed. It was a measure of distance in feet from the impact point to the center of the target and varied with altitude and other conditions.[94] The only available data was an obsolete table gathered from a single B-10 group employing between 4,000 and 18,000 feet.[95] The Air Corps desperately wanted new mean probable error tables, but the data it had sufficed for instructional purposes.

Every bombing probability problem followed the same six-step iterative mechanical process. The Bombardment section recommended selecting complicated targets first and two disparate altitudes since this solution drove conditions for other targets within the complex.[96] Complicated targets included targets with small dimensions requiring large bombs or a large number of required hits.[97] Kuter explained the entire process by walking the class through a single problem. The first

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[91] Kuter, "Practical Bombing Probabilities," 9.
[92] Capt Lawrence S. Kuter, "Practical Bombing Probabilities: Solution of Practical Bombing Probabilities Problem No. 1 with reason why each step is taken" lecture, Air Corps Tactical School, Maxwell AFB, AL, 9 February 1939, in AFHRA, decimal file no. 248.2208A-7 Part 2, 6. This lecture is referred to as "Practical Bombing Probabilities Problem 1".
[93] Kuter, "Practical Bombing Probabilities Problem 1," 12.The majority of targets were not circular so azimuth does affect the solution, but ACTS was unable to address the problem.
[94] Kuter, "Practical Bombing Probabilities Problem 1," 8.
[95] Kuter, "Practical Bombing Probabilities Problem 1," 11.
[96] Kuter, "Practical Bombing Probabilities," 11-12.
[97] Kuter, "Practical Bombing Probabilities Problem 1," 3.

step was to assign the possibility of a hit, the 90 percent chance discussed above. The second step was to assign an altitude that met accuracy and tactical requirements. The third step was to select the appropriate mean probable error from a table. The fourth step was to determine the width and length probabilities based on target geometry. The fifth step was to determine the single shot probability. The sixth step was to interpolate between two charts using the single shot probability to determine the number of bombs required.[98] Planners solved all mathematical equations to three decimal places and then rounded up to determine numbers of bombs, aircraft, flights, squadrons, and groups required to attack a target complex.[99]

The results of the three bombing probability problems presented in the Bombardment course must have been staggering to an aircrew student. The problems generally included a target complex with six DMPIs requiring 88 bombers, more than the entire GHQ Air Force could muster at one time.[100] In a trend that continues to the present, ACTS explored ways to increase accuracy to reduce the size of bomber formations.[101] Kuter argued there were three methods available in 1939. First, lower altitude, which was impractical because of AAA. Second, reduce the probably of a hit from 90% to something lower, but ACTS was unwilling to accept a lower value fearing unsuccessful missions.[102] Kuter suggested the only method to reduce formation size was to reduce the mean probable error. ACTS wanted to reduce the error values in the mean probable error tables because then current data suggested the

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[98] Kuter, "Practical Bombing Probabilities," 14-18.
[99] Kuter, "Practical Bombing Probabilities," 10.
[100] Capt Lawrence S. Kuter, "Practical Bombing Probabilities: Solution of Practical Bombing Probabilities Problem No. 2 with reason why each step is taken" lecture, Air Corps Tactical School, Maxwell AFB, AL, 10 February 1939, in AFHRA, decimal file no. 248.2208A-7 Part 3, 2-3.
[101] Capt Lawrence S. Kuter, "Practical Bombing Probabilities: Conclusion" lecture, Air Corps Tactical School, Maxwell AFB, AL, 13 February 1939, in AFHRA, decimal file no. 248.2208A-7 Part 4, 3.
[102] Kuter, "Practical Bombing Probabilities: Conclusion," 3-5.

error values were too high.[103] In a contrasting statement, Kuter argued mean probable errors should increase based on a fear bombers in combat conditions would be less accurate than in peacetime training sorties.[104] It seemed the Air Corps was relegated to large armadas of bombers flying deep into enemy territory, possibly alone, and hopefully, unafraid.

Bombardment Course Part 3: Tactics and Techniques

The tactics and techniques section of the bombardment course focused on the utility of the formation. Interestingly, Snavely began this portion of the course suggesting formation flying was a limitation and recommended bombers only fly in formation when required.[105] Snavely appeared to be extremely near-sighted, considering the bombing probability lessons made large formations a reality. Formations provided organization for airborne leadership, defensive mutual support, and the required offensive firepower.[106] The phase of flight drove bomber formations to be either administrative, described as a route formation designed for the monotonous drone to and from friendly territory, or tactical, described as either a defensive or offensive formation designed for operations in enemy territory. ACTS stressed the importance of maintaining flexibility by recommending there was no correct formation for the bombardment unit in the air.[107] A fluid situation in the air still required a starting point.

ACTS recommended the constant size of the bomb group and basic formation principles guided formation tactics. For school purposes, the bombardment group consisted of 57 aircraft in a four-squadron group. Each squadron possessed 13 primary assigned aircraft while the group headquarters consisted of five aircraft. A standard group mission

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[103] Kuter, "Practical Bombing Probabilities: Conclusion," 5-6.
[104] Kuter, "Practical Bombing Probabilities: Conclusion,"8.
[105] Capt Ralph A. Snavely, "Formations" lecture, Air Corps Tactical School, Maxwell AFB, AL, 15 February 1939, in AFHRA, decimal file no. 248.2208A-13, 1, 4.
[106] Snavely, "Formations," 4.
[107] Snavely, "Formations," 2-3.

consisted of 36 to 40 aircraft, nine to ten per squadron. The group commander committed aircraft to a mission based on target type, bombing probability, and predicted losses.[108] There were four guiding principles for formations. Formations had to be suitable, flexible, simple, and maneuverable.[109] The suitability requirement drove Snavely to expend little effort on offensive formations since the geometry of the target drove formation geometry.[110] Instead, ACTS focused on defensive formations designed to absorb AAA and repel enemy pursuit attacks.

Antiaircraft Artillery Defenses

Aircrew had to understand the enemy and the enemy's tactics to appreciate their own tactics. The Air Corps perceived American AAA and tactics were superior to any other state; therefore, ACTS based AAA tactics and techniques on the American three-inch gun.[111] The German 3.465-inch gun was larger, but had a slower muzzle velocity and rate of fire than the American gun. Further, foreign tactics were two to three years behind American tactics. Unfortunately, ACTS could not draw upon WW I examples to inform its AAA tactics and techniques. World War I AAA guns were converted field pieces made obsolete by 1930's technology specifically designed for antiaircraft defense. Unlike current AAA tactics, WW I tactics did not mass batteries near projected bomb release lines in all approach directions.[112]

Armed with the specifications of the deadliest AAA piece, the Bombardment course developed a set of assumptions to guide defensive tactics. ACTS believed dense defense would be unusual considering targets would be numerous and geographically separated making it

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[108] Capt Ralph A. Snavely, "Tactical Functions" lecture, Air Corps Tactical School, Maxwell AFB, AL, 17 February 1939, in AFHRA, decimal file no. 248.2208A-14, 1-2.
[109] Snavely, "Formations," 10.
[110] Snavely, "Formations," 21-22.
[111] Capt Lawrence S. Kuter, "Operations with Antiaircraft Artillery Opposition" lecture, Air Corps Tactical School, Maxwell AFB, AL, 20 February 1939, in AFHRA, decimal file no. 248.2208A-16 Part 4, 1-3.
[112] Kuter, "Operations with Antiaircraft Artillery Opposition," 4-5.

difficult for any state to defend even a small fraction of their territory. Prudent instruction led the Bombardment course to focus on heavily defended targets.[113] Examining AAA trajectories suggested bombers were more vulnerable at 4,000 yards then at 12,000 yards. Through chart extrapolation, ACTS arbitrarily decided bombers entered the three-inch gun lethal envelope at 6,000 yards and the 5-inch gun lethal envelope at 7,500 yards.[114] There was safety in numbers.

ACTS designed AAA tactics and techniques to reduce each bomber's vulnerability.[115] There were five AAA defensive formation design requirements. First, each aircraft needed sufficient space to maneuver in all three dimensions. Second, each aircraft required adequate spacing to ensure a single shell did not damage more than one aircraft. Third, the formation must be sufficiently condensed to reduce each aircraft's vulnerability to a single shot from any one gun. Fourth, the formation must gain an advantage by incorporating meteorological conditions. Fifth, the formation must be flexible enough to convert to an offensive formation or a pursuit defensive formation.[116] The properly designed formation utilized the least vulnerable ingress/egress axis, maintained maximum airspeed, and employed from high altitude to minimize the number of AAA rounds.[117] Avoiding the *Fliegerabwehrkanone* (flak) was challenging if it was un-located.

The Bombardment course recommended methods to mitigate AAA during mission planning. Bomber planners required an enemy AAA order of battle to plan ingress and egress routes; unfortunately, AAA

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[113] Kuter, "Operations with Antiaircraft Artillery Opposition,"6.
[114] Kuter, "Operations with Antiaircraft Artillery Opposition," 8-9.
[115] Kuter, "Operations with Antiaircraft Artillery Opposition,"9.
[116] Snavely, "Formations," Chart B-13-C.
[117] Capt Ralph A. Snavely, "Day Attack with Antiaircraft Opposition" lecture, Air Corps Tactical School, Maxwell AFB, AL, 21 February 1939, in AFHRA, decimal file no. 248.2208A-16, 7; Kuter, "Operations with Antiaircraft Artillery Opposition," 16. The AAA tactics taught at the School were developed, tested, and approved by line bomb squadrons opposed by line AAA regiments, both simulating combat conditions as close as possible.

batteries were hard to locate. ACTS advocated a good bombardment intelligence staff could develop an estimated AAA order of battle by using the location of one known battery to estimate the locations of other batteries based on enemy tactics. If all AAA batteries were un-located, the intelligence staff developed an estimated AAA order of battle based on the location of the target and enemy tactics.[118] Snavely recommended target back planning. Each mission began by plotting the target, drawing a straight line between the target and formation assembly point, and deviating only for enemy AAA, troop concentrations, front lines, hostile pursuit bases, and large cities.[119] Eventually, the bombers had to commit to the target.

Offensive considerations took priority over defensive considerations. Formation altitude was a factor of both the bombing probability and AAA; however, the bombing probability was the priority and drove the final altitude selection.[120] Planners selected an initial point shifting the formation from a defensive mindset to an offensive mindset by assuming the offensive formation. The Bombardment course failed to mention a specific offensive formation; however, the faculty recommended the group stagger. The stagger, flown at AAA intervals, was a good defensive and offensive formation suggesting the Air Corps was in the midst of changing doctrine.[121] Kuter stated ACTS arbitrarily developed 500 feet spacing between bombers to mitigate the effects of a single shell while providing maneuvering airspace for individual bombers.[122] Regardless whether the formation was defensive or

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[118] Kuter, "Operations with Antiaircraft Artillery Opposition," 10.
[119] Snavely, "Day Attack with Antiaircraft Opposition," 14.
[120] Snavely, "Day Attack with Antiaircraft Opposition," 12.
[121] Snavely, "Day Attack with Antiaircraft Opposition," 12-13. A description of the group stagger formation is not required. The significance of the stagger was ACTS appeared to believe it sufficed as both a defensive and offensive formation after advocating there was never a correct bomber formation.
[122] Kuter, "Operations with Antiaircraft Artillery Opposition," 15-16.

offensive, the bomber could take advantage of its low observable qualities.

The Bombardment course advocated the best defense against AAA in day and night missions was invisibility. Kuter provided two examples to illustrate the effectiveness of invisibility. In the first example, observers failed to identify bombers executing bomb runs at both 12,000 feet and 4,700 feet until after their weapons struck their targets. In the second example, Kuter provided a personal experience in which bombers executed a simulated bomb run on a target at 12,000 feet. Several hundred people, including him, could hear the bombers, but none of them saw the bombers until they were outbound after a successful release. ACTS defined invisibility as the ability of the bombardier to see the target while ground observers located near the target could not acquire the bomber.[123] Another aspect of invisibility, especially at night, was inaudibility. AAA batteries used sound locators to cue searchlights. Kuter stated clean aircraft design, propeller design, low propeller tip speed, and muffled engine exhaust contributed to quieter aircraft.[124] Reliance on crude low observable qualities was a common theme for the noisy bombers spewing long, wispy contrails.

Pursuit Defense

Advanced fighters emerged across the Atlantic posing a serious challenge to the bombers, even to the four-engine Flying Fortress. ACTS revealed the RAF employed a high performance fighter superior in performance to the B-10, B-17, and the B-18, but failed to specify a particular aircraft. Two fighters fit the description.[125] The RAF began assigning Hurricanes to squadrons in November 1937 while Spitfires started appearing in squadrons less than a year later in August 1938.[126]

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[123] Kuter, "Operations with Antiaircraft Artillery Opposition," 11-14
[124] Kuter, "Operations with Antiaircraft Artillery Opposition," 14-15.
[125] Snavely, "Formations," 6-7.
[126] Stephen Bungay, *The Most Dangerous Enemy: A History of the Battle of Britain*, Reissued ed. (London, UK: Aurum Press, 2009), 75, 80.

RAF tactics for these nimble fighters included single ship attacks in a climb from beneath the bomber formation.[127] ACTS believed RAF tactics were less-advanced than Air Corps tactics and suggested Air Corps tactics were the most effective pursuit tactics ever devised. Therefore, they used these to develop bomber tactics and techniques.[128] In a time without the benefit of radar, finding bombers was a challenge.

The pursuit force relied on an interception network to locate enemy aircraft. The Bombardment course, referencing the pursuit course, recommended an ineffective interception network handicapped the effectiveness of fighters to locate and repel enemy aircraft in a timely manner. Snavely likened penetrating an interception network to penetrating hostile AAA at night. The best technique to avoid the interception network was to be invisible and inaudible.[129] Accepting this technique was impractical, ACTS assumed an interception network always identified a bomber formation audibly as "many airplanes – very high."[130] The task of the bomber formation was to limit the amount of information an interception network collected.

There were methods to mitigate the effectiveness of an interception network. The best method to penetrate an interception network was to utilize a straight course across the network at maximum speed to reduce the vulnerability period.[131] Large altitude variations, while in an interception network, also decreased the possibility of a successful pursuit interception.[132] ACTS recommended flying in solid clouds or through heavy broken clouds, preventing the interception network from observing, counting, and describing aircraft.[133] ACTS assumed pursuit

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[127] Snavely, "Formations," 6-7.
[128] Capt Ralph A. Snavely, "Bombardment with Pursuit Opposition" lecture, Air Corps Tactical School, Maxwell AFB, AL, 1 March 1939, in AFHRA, decimal file no. 248.2208A-21, 5-6.
[129] Snavely, "Bombardment with Pursuit Opposition," 10-11.
[130] Snavely, "Bombardment with Pursuit Opposition," 11.
[131] Snavely, "Bombardment with Pursuit Opposition," 12.
[132] Snavely, "Bombardment with Pursuit Opposition," 13-14.
[133] Snavely, "Bombardment with Pursuit Opposition," 11.

interception in clouds would be as difficult as forming a large bomber formation in clouds, but clouds made it impossible to bomb.[134] Camouflage had advantages and disadvantages as well. Scattered clouds hid camouflaged aircraft from ground observers, but camouflaged aircraft stood in stark contrast against a solid cloud deck or a clear sky.[135] Electronic warfare was in its infancy as ACTS explored jamming pursuit radio networks with cricket sirens; however, technology also existed for fighters to home on the jamming signal.[136] Surprisingly, the Bombardment course made no mention of radar, the technological breakthrough that solved the interception problem.[137] Lacking knowledge of this revolutionary system led the Bombardment course to a faulty assumption.

ACTS planned for the worst, but expected the best. Indicative of the AAA lesson, ACTS believed effective pursuit defense would be rare given the target/geography ratio discussed above and advised the majority of bomber missions would go unopposed from enemy fighters.[138] Target complexes defended by pursuit required all available bombers to ensure target destruction since losses were expected.[139] Accordingly, ACTS recommended friendly fighter escort was highly desired on these missions.[140] The Bombardment course instructors realized the fighter's range was severely limited compared to the bomber and submitted to motivational speeches such as "we believe that a bombardment unit, worth its salt, is imbued with the determination that it will penetrate any

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[134] Snavely, "Bombardment with Pursuit Opposition," 13.
[135] Snavely, "Bombardment with Pursuit Opposition," 11-12, 14. ACTS also explored methods to apply camouflage to aircraft prior to takeoff based on weather forecasts.
[136] Snavely, "Bombardment with Pursuit Opposition," 15.
[137] Bungay, *The Most Dangerous Enemy*," 61. Britain had demonstrated a radar capability as early as 1937.
[138] Snavely, "Bombardment with Pursuit Opposition," 20.
[139] Capt Ralph A. Snavely, "Illustrative Problem 4 Solution" lecture, Air Corps Tactical School, Maxwell AFB, AL, 2 March 1939, in AFHRA, decimal file no. 248.2208A-21 Part 1, 9.
[140] Snavely, "Bombardment with Pursuit Opposition," 4.

pursuit force in the world."[141] The bombers would be alone, but they were still lethal to enemy fighters.

The Bombardment course suggested formation integrity was vital for enough of a bomber formation to survive enemy fighter-infested skies.[142] The underlying principle was mutual support. A separated bomber, acting like a scared cockroach, was an easy target for a flight of enemy fighters, but a formation with interlocking fields of fire was formidable opposition.[143] Once again, as with the AAA lesson, ACTS suggested the stagger formation provided sufficient mutual support and provided no other formation recommendations.[144] The stagger protected against attacks from below, behind, and on the flanks of the formation. A bomber formation took advantage of the ability to counter the fighter's fixed gun with the bomber's flexible guns.[145] No matter how frightening or effective, ACTS claimed that bombers would never turn back because of enemy fighters.[146]

Conclusion

The Bombardment course dealt primarily with the means of tactical destruction, but hinted at the ways of strategic effects. Kuter described the demolition bomb as the cornerstone of the Air Corps and was the key to applying pressure to a state's commercial, economic, industrial, and social fabric.[147] Bombing was "Big Business" and was more complex than "simple soldiering."[148] The Bombardment course highlighted the coercive character of airpower and the demolition bomb, citing the Munich Pact as an example of a strong airpower state acquiring what it demanded in the face of Europe's large armies and

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[141] Snavely, "Bombardment with Pursuit Opposition," 6.
[142] Snavely, "Bombardment with Pursuit Opposition," 2.
[143] Snavely, "Bombardment with Pursuit Opposition," 8.
[144] Snavely, "Illustrative Problem 4 Solution," 11.
[145] Snavely, "Formations," 7-9; 13-20.
[146] Snavely, "Bombardment with Pursuit Opposition," 9.
[147] Kuter, "The Power and Effect of the Demolition Bomb," 2-3.
[148] Snavely, "Tactical Functions," 7.

navies.[149] ACTS believed states were scrambling to acquire large bombardment forces to match the Luftwaffe and believed "God is on the side which has the most heavy bombardment units."[150] The anointed air force would quickly employ the demolition bomb to prohibit an enemy from employing its own air force and from building an air force after a formal declaration of war.[151] The Air Corps was behind the power curve.

A theme of humility emerged during portions of the Bombardment course. Kuter was disgusted with the history of Air Corps bombing and opined it was "obviously a sorry one." Squadron commanders had prioritized training on other aspects of flying instead of focusing training on bombing proficiency.[152] He also believed the history of Air Corps interest in its ability to bomb was "still sorrier."[153] Bombing probabilities provided the Air Corps with a method to plan bombing missions, but the Air Corps had failed to keep probability error tables updated. The non-current tables meant planners could not accurately plan bombing missions. The Air Corps had just begun to rectify this dire situation as the world began to unravel.[154]

[149] Snavely, "Orientation – Bombardment Aviation," 3-3A.
[150] Snavely, "Orientation – Bombardment Aviation," 3A.
[151] Snavely, "Orientation – Bombardment Aviation," 3B.
[152] Kuter, "Practical Bombing Probabilities: Conclusion," 23.
[153] Kuter, "Practical Bombing Probabilities: Conclusion," 10.
[154] Kuter, "Practical Bombing Probabilities: Conclusion," 10-17. The Air Corps assigned a physicist to ACTS to analyze current bombing data and develop new probability error tables.

Chapter 3

The Attack Course

The attack of aircraft upon ground troops, using machine guns and bombs showed very clearly that this had a most demoralizing effect. It will be well to specialize in this branch of aviation and to provide squadrons or groups with armored airplanes provided with machine guns and small bombs for just such work against ground objectives.

Chief of Air Service, American Expeditionary Force (WW I)

The Attack course epitomized the struggle between the Army and its Air Corps. The Army saw in the attack aircraft a powerful weapon capable of direct support to ground forces in contact with the enemy, while the Air Corps believed the attack aircraft was too expensive a weapon to use in this role. ACTS designed the Attack course to explain this rationale and the proper use of the attack aircraft. ACTS believed the best way to support ground forces incorporated attacks against ammunition and supply dumps, advancing reserve forces, and adversary lines of communications forcing the enemy to retreat after expending what ammunition and supplies were on the front lines.[1] The course consisted of 19 lectures, one quiz, eight illustrative problems, and three map problems.[2] The course began in early January 1939 and ended two weeks into February easing the students into the Bombardment course.

The Attack instructors presented the course in three sections. The first section introduced the student to attack aviation. The second section focused on capabilities and limitations of both the aircraft and the weapons. The focus of the Attack course was in the final section. This section stressed the practical application through study of the

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[1] Capt Ralph F. Stearley, "History, Development, Organization, Training" lecture, Air Corps Tactical School, Maxwell AFB, AL, 3 January 1939, in AFHRA, decimal file no. 248.2208B-1, 10.

[2] ACTS, "Form 1" for the "Attack" course, 1938-1939, in AFHRA, decimal file no. 248.2208B.

tactics and techniques of the attack aircraft. The attack target set was diverse; therefore, the Attack course provided the basic principles and one example for each target type, and instructed the student to apply these general principles to any situation falling within the attack mission set.[3] Before the student could do this, he needed a history lesson.

Attack Course Part 1: Introduction to Attack Aviation

The concept of attack aviation partially developed from bored pilots with an itchy trigger finger. World War I aircrew, returning from deep strikes into enemy territory, realized they could aid their brothers on the ground by dropping unexpended bombs and grenades on enemy troops as they crossed over the front. Meanwhile, the Allied Powers in WW I had quickly learned it was safer and easier to destroy aircraft while they were still on the ground. The Attack course suggested this was the birth of attack aviation. Technological advances in the form of fixed forward firing machine guns and bomb racks enabled attack aviation to develop rapidly. By the end of the war, both the Allied and Central Powers organized large attack formations tasked against enemy ground forces, usually in coordination with major ground offensives.[4] ACTS also highlighted the use of attack assets against German airfields basing enemy attack aircraft used to pummel the Allied lines. Captain Ralph Stearley argued these missions represented the proper use of attack assets to strike Counterair targets and served as indirect, close, and immediate support of ground troops.[5]

The "Attack" textbook defined attack aviation as the component of an air force organized, trained, and equipped primarily to destroy light material objectives and personnel. The distinctive factor of attack operations were assaults at minimum altitude covered by a heavy volume

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[3] Capt Ralph F. Stearley, "Tactics and Technique of Attack Aviation" lecture, Air Corps Tactical School, Maxwell AFB, AL, 10 January 1939, in AFHRA, decimal file no. 248.2208B-8, 2.
[4] Stearley, "History, Development, Organization, Training," 6.
[5] Stearley, "History, Development, Organization, Training," 9.

of forward machine gun fire. The two functions of attack were Counterair, accomplished by attacking airfields and suppressing AAA, and Counterland, accomplished by deep interdiction of ground supply systems and coastal defense operations.[6] Attack aviation specifically did not include close air support of friendly troops in contact with enemy ground forces. The Attack course referenced a letter from the Adjutant General originating from the Secretary of War dated 9 Sept 1938 to support the official ACTS position. The letter highlighted the limited availability of attack assets and the time and expense required to replace aircraft. The letter stated the Air Corps should limit the use of attack assets in high threat environments to high priority decisive targets taking advantage of surprise. The letter further directed the Army to utilize another weapons system capable of providing the same effect that was less vulnerable to attack and less valuable. The Air Corps interpreted this to mean the Army should use artillery to support troops in contact with the enemy instead of attack aviation assets.[7] One reason for the harsh stance against close air support may have been the feeble size of the Air Corps' attack force.

Attack organization was similar to bombardment, but the nature of the mission and aircraft drove the attack group to function differently since the majority of attack targets were squadron targets.[8] In 1939, the Air Corps had two attack groups and an additional attack squadron. A group consisted of four squadrons, each equipped with 25 aircraft; however, the Air Corps considered squadron combat strength to be 18 aircraft equating to a group combat strength of 72 aircraft. Group commanders remained on the ground if only one or two of their

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[6] Capt Ralph F. Stearley, "Basic Principles of Employment" lecture, Air Corps Tactical School, Maxwell AFB, AL, 3 January 1939, in AFHRA, decimal file no. 248.2208B-1, 1. Note: this lecture is in the same file as "History, Development, Organization, Training.";Stearley, "History, Development, Organization, Training," 10.
[7] Stearley, "Basic Principles of Employment," 5.
[8] Stearley, "History, Development, Organization, Training," 17.

squadrons had assigned missions.[9] Each squadron consisted of two flights of 12 aircraft, leaving one aircraft for the commander. An airborne flight consisted of nine aircraft, separated into three elements. The group and squadron were tactical and administrative units allowing the flights and elements to focus on the tactical mission.[10] The flight was capable of independent action, since it could defend itself from enemy fighters. The element was the basic assault unit and consisted of three aircraft providing mutual support. The Attack course stressed the importance of element training and low altitude formation flight training in order to attain and maintain proficiency.[11] Unlike bombers with large crews to distribute the workload, attack aircraft challenged one busy pilot and an underemployed gunner.

The design of the A-17 attack aircraft incorporated a tandem cockpit accommodating one pilot in the forward cockpit and a gunner in the rear cockpit. The gunners were only trained to fire one of five machine guns (discussed in Part 2), highlighting an imbalance of crew duties. In an effort to make the gunner more efficient, ACTS recommended gunners be competent in radio repair and qualified to load munitions and service the aircraft.[12] The attack pilot performed more duties than bomber or pursuit pilots did. The pilot was responsible for navigation, firing the four other machine guns, and releasing weapons, all while flying formation at low altitude in a non-permissive environment, sometimes at night.[13] The multitasking attack pilot needed an intimate relationship with his aircraft.

Attack Course Part 2: Capabilities and Limitations

The attack pilot approached his profession differently than a bomber pilot. Bomber aircrew focused heavily on weapons effects and

[9] Capt Earl W. Barnes, "Operations of Attack Aviation" lecture, Air Corps Tactical School, Maxwell AFB, AL, 9 January 1939, in AFHRA, decimal file no. 248.2208B-7, 6.
[10] Stearley, "History, Development, Organization, Training," 10-11.
[11] Stearley, "History, Development, Organization, Training," 16.
[12] Stearley, "History, Development, Organization, Training," 13-14.
[13] Stearley, "History, Development, Organization, Training," 14.

mission planning against a fixed target, while the attack pilot focused on the tactics and techniques required to operate in a dynamic environment where the target description and location may be unknown. The Attack section designed the capabilities and limitations portion of the course to highlight the strengths and weaknesses of the attack aircraft and associated weapons to prepare the student for an intense tactics and techniques section. Unlike the Bombardment course, ACTS considered practical application more important than the mechanics of weapons effects for the Attack course. The Attack arm also did not have a state-of-the-art aircraft such as the B-17; this was apparent given the amount of instruction devoted to requirements and future aircraft.[14]

The Aircraft

The requirements for an attack aircraft were a unique combination of aircraft performance and specialized capabilities. An attack aircraft had to be capable of carrying a practical weapons load far enough to reach targets behind enemy lines and area bomb at minimum altitude.[15] ACTS wanted a combination of high speed at low altitudes, increased range, and silence to enable self-escort against enemy fighters, reduce the vulnerability against surface fire, and provide a fuel reserve.[16] A defensive gun position covering the rear hemisphere enhanced self-escort. The Attack section endorsed only incorporating minimal armor to protect the aircrew allowing for a heavier weapons load.[17] Takeoff and landing requirements included the ability to operate continuously from grass fields with 3,000-foot runways and 50-foot obstacles at either end while the only ceiling requirement was the ability to cross the "highest mountain ranges."[18] Finally, ACTS recommended the aircraft should have an enclosed cockpit to protect the crew from cold, wind, and noise

[14] Capt Earl W. Barnes, "The Attack Airplane" lecture, Air Corps Tactical School, Maxwell AFB, AL, 5 January 1939, in AFHRA, decimal file no. 248.2208B-2, 16.
[15] Barnes, "The Attack Airplane," 1-2.
[16] Barnes, "The Attack Airplane," 4.
[17] Barnes, "The Attack Airplane," 5-6.
[18] Barnes, "The Attack Airplane," 4-5.

to maximize aircrew efficiency while at the same time maximizing the forward and downward visibility for target identification and attack.[19] The Air Corps had to settle for an aircraft that met some, but not all of these design desires.

The primary attack aircraft was the unarmored, two-seat, single-engine A-17 capable of carrying a diverse weapons load.[20] The A-17's design incorporated machine guns, external bomb racks, and a small internal bay. The aircraft had four .30-caliber fixed forward firing machine guns and one .30-caliber flexible machine gun for the rear quadrant. The external bomb rack configuration included carriage capacity for four 100-pound demolition bombs or two chemical spray containers. The internal bay consisted of a bomb rack capable of carrying 20 small fragmentation or chemical bombs.[21] Total carriage capacity depended on mission distance. The A-17 always carried the machine guns and 3,000 rounds of .30-caliber ammunition. On combat missions shorter than 450 miles, an A-17 carried a full complement of internal and external weapons while on missions longer than 450 miles an A-17 only carried either an internal or external weapons load.[22] Unfortunately, the A-17 fell short of ACTS' expectations. It was considerably slower than its counterparts in England, Germany, and Japan.[23] Bomber targets were also considerably further away than 450 miles.

The dual nature of the attack mission led the Attack course instructors to ponder the viability of a single aircraft to fulfill the

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[19] Barnes, "The Attack Airplane," 5-6.
[20] Stearley, "History, Development, Organization, Training," 12-13.
[21] Capt Ralph F. Stearley, "Attack Weapons and Equipment" lecture, Air Corps Tactical School, Maxwell AFB, AL, 5 January 1939, in AFHRA, decimal file no. 248.2208B-4, 1-2, 18; Capt Ralf F. Stearley, "Attack Weapons. Chemicals and Chemical Dispersion" lecture, Air Corps Tactical School, Maxwell AFB, AL, 6 January 1939, in AFHRA, decimal file no. 248.2208B-6, 7.
[22] Stearley, "Attack Weapons and Equipment," 2.
[23] Barnes, "The Attack Airplane," 15-16. The A-17 was slower than the British Fairey Battle Raider, the German JU-87, and the Mitsubishi 97.

spectrum of both Counterair and Counterland requirements. To support the bombers on distant missions, ACTS recommended a long-range attack aircraft was mandatory, but acknowledged this aircraft would be inefficient against much closer Counterland targets. One solution to this problem was to adapt some of the bombers to low-altitude operations relieving attack from AAA suppression duties. Another solution incorporated a larger attack aircraft for Counterair missions and a smaller attack aircraft for Counterland missions. In 1939, the Air Corps was not acquiring an attack aircraft to carry out long-range missions; however, the Air Corps was investigating the feasibility of a larger, faster, twin-engine attack-bomber.[24]

While bombardment reaped the benefits of the technological revolution, attack wallowed in a mire of industry failure. The A-17 met the majority of the Air Corps' requirements, but was too slow to keep up with fighters because it only had one engine.[25] The Attack course suggested a two-engine attack aircraft made up for the shortfalls of the A-17 in speed and increased the weapons capability; however, the A-18 did not support this claim.[26] The Air Corps was retiring its 13 twin-engine A-18 aircraft because their performance was sub-standard to A-17 performance.[27] Meanwhile, two twin-engine, high-speed attack aircraft, the British Bristol Blenheim bomber and Italian Breda-88, succeeded where the A-18 failed.[28] Refusing to buck technology from a strong desire for a better aircraft, the Attack instructors believed a successful attack-bomber was in their future and felt compelled to describe its awesome capabilities.

The future attack-bomber requirements created a new aircraft that looked more like a bomber than it did a fighter, indicating the Air Corps

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[24] Barnes, "The Attack Airplane," 6-7.
[25] Barnes, "The Attack Airplane," 8.
[26] Barnes, "The Attack Airplane," 9.
[27] Stearley, "History, Development, Organization, Training," 12; Barnes, "The Attack Airplane," 10-11.
[28] Barnes, "The Attack Airplane," 15.

was struggling with its attack identity. ACTS predicted the future Air Corps' twin-engine attack aircraft would eventually be the same size and weight as the A-18, but faster, with double the weapons carriage capacity, and a larger crew.[29] The Air Corps specification requirements for an attack-bomber dated 13 Sept 1938 required the aircraft to satisfy Counterland and Counterair mission sets (except for long-range AAA suppression) with a range of 1,200 miles, capable of both precision and area bombing. The aircraft's maximum weapons load had to be 1,200 pounds, while carriage capability had to include all then-current attack weapons, 300-pound, and 600-pound demolition bombs. Unlike its predecessor, this aircraft would be capable of attacking concrete bridges, steel railroad bridges, subways, buildings (except skyscrapers), naval vessels (except battleships and cruisers), and concrete docks. The Attack course recommended an attack-bomber used against these target sets became a short-range bomber governed by bombardment principles.[30] The Air Corps was getting a new bomb dropper, but it still did not possess an aircraft capable of long-range AAA suppression.

The Weapons

The forward-firing machine gun separated the attack aircraft from the bombers. The guns, mounted in the wings, had a one-degree vertical and lateral adjustment and an effective range of 800 to 1,000 yards.[31] Pilots fired the guns singly, in pairs, or simultaneously utilizing a trigger on the stick.[32]The machine gun rate of fire was 1,200 rounds per minute, but the aircraft only carried 600 rounds per each gun limiting operation to 30 seconds per gun.[33] The Air Corps struggled with barrel overheating, and ACTS recommended replacing the barrels after every

[29] Barnes, "The Attack Airplane," 11.
[30] Barnes, "The Attack Airplane," 11-14.
[31] Barnes, "The Attack Airplane," 3, 7.
[32] Barnes, "The Attack Airplane," 4.
[33] Barnes, "The Attack Airplane," 2-3.

mission.[34] The three standard types of ammunition were armor-piercing, ball, and tracer. Armor-piercing ammunition penetrated a one-eighth-inch steel plate at 800 yards. The Attack course reserved ball ammunition for use against personnel. Aircraft speeds negated the traditional use of tracers, aiding operator aiming, but was effective at igniting aircraft fires. ACTS recommended using armor-piercing rounds for all missions except for Counterair missions. On Counterair missions, ACTS recommended armor piercing rounds with every fifth round being a tracer.[35] Pilots enjoyed the protective blanket of their machine guns, but feared what might happen if an enemy armor-piercing round found one of their demolition bombs.

Attack and bombardment employed the same standard 100-pound demolition bomb utilizing an instantaneous or delay fuze. External racks, located between the landing gear, provided carriage for up to four munitions. The pilot electrically actuated the bomb racks, capable of single, trail, or salvo (all four at once) releases, with a button on top of the control stick.[36] The fragmentation pattern drove a minimum safe release altitude of 1,000 feet.[37] Given ball and tracer .50-caliber rounds caused low-order detonations in 100-pound demolition bombs out to 50 feet, an unintended positive consequence of this high release altitude, by attack standards, was to eliminate a ground threat. Pilots still had to contend with armor-piercing rounds capable of causing low-order detonations out to 1,000 feet.[38] A high-order detonation; however, was much more destructive than a low-order fizzle.

The Attack course focused less on weapons effects than bombardment did, but still covered the basics. The Attack course recommended the best weapon for ammunition and supply dumps was

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[34] Barnes, "The Attack Airplane," 5-6.
[35] Stearley, "Attack Weapons and Equipment," 9-10.
[36] Stearley, "Attack Weapons and Equipment," 10.
[37] Stearley, "Attack Weapons and Equipment," 11.
[38] Barnes, "Operations of Attack Aviation," 17-18.

the 100-pound instantaneous-fuzed demolition bomb. Similarly, the best weapon for light factories, wooden docks, hangers, oil refineries, rail tracks, highways, wooden and pontoon bridges, and small naval vessels was the 100-pound delay-fuzed demolition bomb.[39] Testing indicated a 100-pound demolition bomb sufficiently buried itself at a 400-foot release altitude to achieve the same effects as at 1,000 feet, but required a five or ten second delay fuze indicating the Attack course instructors shared the same desire as the Bombardment course instructors did for more fuzing options. The Air Corps was also developing a high drag capability to retard the fall enabling aircraft to release at lower altitudes.[40] High drag devices proved to be effective for munitions that were smaller, but just as lethal.

The A-17 carried fragmentation bombs internally. The bomb rack provided carriage for 20 weapons and was located in the fuselage between the pilot and gunner. It incorporated a vertical system inclined 15 degrees aft to allow the bombs to drop easily. The pilot either released the weapons singly or in train by actuating the same button on the stick used to release the external weapons. A toggle switch allowed the pilot to select either external or internal weapons. Two separate tail kits provided for a low drag and high drag option.[41] The minimum safe altitude for the low drag fin-configured fragmentation bomb was 800 feet while the minimum safe altitude for the high drag parachute-configured fragmentation bomb was 65 feet.[42] The parachute retarded the vertical and forward movement of the fragmentation bomb, traveling forward from the release point a distance of 65 yards while the aircraft traversed 300 yards in the same time.[43] The aircraft need an opportunity to escape a fragmentation bomb's destructive effects.

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[39] Stearley, "Attack Weapons and Equipment," 11.
[40] Stearley, "Attack Weapons and Equipment," 11-12.
[41] Stearley, "Attack Weapons and Equipment," 12.
[42] Stearley, "Attack Weapons and Equipment," 13.
[43] Stearley, "Attack Weapons and Equipment," 16.

Fragmentation bombs functioned fundamentally differently from a demolition bomb. The munition created effects by exploding into 800 to 1,400 small fragments travelling at high speed. ACTS likened these fragments to the effectiveness of small-arms ammunition at distances of 50 yards and greater. A fragmentation bomb attains its maximum effectiveness when detonated in a vertical position, enabling the fragments to expand in every lateral direction.[44] The wall of the fragmentation bomb was a series of spiral rings fitted over a thin steel tube containing a bursting charge.[45] The 30-pound fragmentation bomb contained only 4.75 pounds of TNT. The blast effect at one foot compared to the blast effect at 12 feet for a 100-pound demolition bomb requiring a direct hit to be effective on tanks, trucks, and similar vehicles.[46] Stearley provided an example where a test against a B-6 demonstrated a 30-pound fragmentation bomb was more effective than a 100-pound demolition bomb. The 17-pound fragmentation bomb was effective against fuel tanks and aircraft within 200 feet so the Attack course assumed the 30-pound fragmentation bomb, without supporting data, would be at least as effective.[47] Attack aircraft were also capable of non-kinetic attacks.

Chemical warfare was an integral part of the attack arsenal. In 1939, chemical warfare carried a confidential classification as every major state researched new chemicals and dispersion methods keeping close tabs on each other.[48] ACTS suggested the potential effects of chemical attack were expensive, forcing an enemy to provide protective gear for all personnel and decontamination equipment at all permanent and semi-permanent installations at a high cost.[49] Air-delivered chemical weapons created effects in four different manners. First,

[44] Stearley, "Attack Weapons and Equipment," 14.
[45] Stearley, "Attack Weapons and Equipment," 12.
[46] Stearley, "Attack Weapons and Equipment," 15.
[47] Stearley, "Attack Weapons and Equipment," 17.
[48] Stearley, "Attack Weapons. Chemicals and Chemical Dispersion," 1.
[49] Stearley, "Attack Weapons. Chemicals and Chemical Dispersion," 5.

chemical weapons created casualties. Second, chemical weapons denied enemy access to key areas—airfields, avenues of approach, and key terrain—through contamination. Third, chemical weapons contaminated enemy material and supplies such as aircraft, munitions, and food. Fourth, chemical weapons threatened hostile personnel and equipment, delayed operations, required personnel to wear protective equipment, and required decontamination facilities.[50] Chemical weapons were nasty and required special procedures.

Three chemical types existed for use in air warfare, but their characteristics limited the ability of the Air Corps to employ or train with them. Mustard gas was the standard vesicant weapon for contamination; however, the Air Corps severely restricted the use of mustard gas during peacetime. Smoke was the standard weapon for obscuration. The Attack course suggested smoke protected attack units approaching a target, protected attacking bombers from AAA, and protected friendly beach-landing forces. The Air Corps was less restrictive with smoke use in peacetime, but smoke was dangerous enough to warrant the Air Corps directing ACTS to include smoke dispensing precautionary measures in the Attack syllabus.[51] The Attack course further recommend avoiding smoke screen use for attack units as it sacrificed surprise.[52] Stearley advocated the Air Corps needed a satisfactory chemical to use in an incendiary bomb. Thermite failed expectations and white phosphorous was not meeting the Air Corps' standard.[53] Regardless of the restrictions, the A-17 was effective at delivering these vile agents.

Two methods existed to deliver chemical weapons from an attack aircraft. The first method utilized a spray system to disperse chemicals in the atmosphere. The spray tank resembled the shape and size of a

[50] Stearley, "Attack Weapons. Chemicals and Chemical Dispersion," 4.
[51] Stearley, "Attack Weapons.Chemicals and Chemical Dispersion," 10.
[52] Stearley, "Attack Weapons. Chemicals and Chemical Dispersion," 13-14.
[53] Stearley, "Attack Weapons. Chemicals and Chemical Dispersion," 6.

300-pound demolition bomb with a 20-gallon capacity. A maximum of two tanks were suspended from the racks used for 100-pound demolition bombs and could be jettisoned in flight.[54] The second method utilized a bomb delivery system in two different ways. The chemical bomb contained mustard gas, tear gas, or white phosphorus and weighed between 28 and 32 pounds depending on the chemical. The only fuzing option was an instantaneous nose fuze that dispersed the chemicals 15 yards laterally and 10 yards vertically upon impact.[55] The innovative 11-pound "tin can" bomb was the preferred bomb of the Attack course. Utilizing commercial-off-the-shelf technology, the Air Corps filled a tin can with a gallon of chemicals that burst open upon impact. A double "tin can" contained 2 gallons and weighed 21 pounds unlike the heavier chemical bomb containing less than a gallon of chemicals.[56] The "tin can" increased the maximum chemical load of the A-17 to 80 gallons, 40 gallons in spray tanks and 40 gallons in "tin can" bombs.[57] The innovation of the "tin can" bomb was an example of attack's flexibility, a trait attack needed to survive in the dynamic environment of attack operations.

Attack Course Part 3: Tactics and Techniques

An attack assault took advantage of the synergistic effects of the attack aircraft's different munition capabilities. Machine gun fire covered the approach to the target and incidentally caused casualties. ACTS recommended grazing fire versus plunging fire. Grazing fire increased the bullets' effective zone and caused ricochets while plunging fire simply buried itself in whatever it hit.[58] Fragmentation bombs and demolition bombs destroyed objects and caused casualties while chemicals

[54] Stearley, "Attack Weapons. Chemicals and Chemical Dispersion," 7-8.
[55] Stearley, "Attack Weapons and Equipment," 18.
[56] Stearley, "Attack Weapons.Chemicals and Chemical Dispersion," 17.
[57] Stearley, "Attack Weapons.Chemicals and Chemical Dispersion," 13.
[58] Stearley, "Attack Weapons and Equipment," 7.

neutralized and contaminated targets.[59] Attack aircraft were suitable platforms for chemical dispersion because of the aircraft's ability to control dispersion and low altitude performance.[60]

Attack units operated at the minimum altitude that only provided obstacle clearance. Low altitude operations enabled surprise, increased weapon accuracy and effectiveness, minimized ground fire exposure, and afforded protection against enemy fighters.[61] The Attack course suggested attack aircraft were self-escorting assets operating at minimum altitudes ensuring enemy fighters could not attack from below and expected the majority of engagements to occur aft of the formation. ACTS, confident in the flexible machine gun, suggested fighter engagements would result in attack formation survival and heavy pursuit losses.[62] Considering AAA was ineffective at low altitude, the Attack course was concerned more with enemy fighters than small arms fire, effective up to 2,500 feet, and relied on speed and surprise to limit the small arms fire vulnerability.[63] Operating at minimum altitudes took its toll on pilots; proper route planning provided the pilots a break enabling them to fly at higher altitudes.[64]

The dynamic environment of the attack mission prevented mission planners from detailed planning of entire missions. The Attack course recommended the minimum information required to plan was target type, general location, and time on target (TOT). The group was the standard unit to begin planning, but often a squadron was only necessary to perform the task. The planner selected the weapons load based on the target and the tasking (delay, neutralize, destroy, or

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[59] Stearley, "Tactics and Technique of Attack Aviation," 2.
[60] Stearley, "Attack Weapons. Chemicals and Chemical Dispersion," 6-7.
[61] Barnes, "Operations of Attack Aviation," 12.
[62] Stearley, "Basic Principles of Employment," 13; Barnes, "Operations of Attack Aviation," 14.
[63] Barnes, "Operations of Attack Aviation," 14-15.
[64] Barnes, "Operations of Attack Aviation," 12.

contaminate) from higher headquarters.[65] Chemical weapons required special fratricide considerations, ensuring friendly ground forces or future ground objectives were not contaminated.[66] For missions without an exact target location or for moving targets, ACTS advocated for an observation unit to provide a target location, or for an attack element or flight to serve in an armed reconnaissance role. Acting in this role, the element or flight arrived at the general target location before the assigned TOT, located the target, and transmitted the location to the main attacking force.[67] As in bombardment mission planning, the attack planner started at the target with a specific TOT and worked backwards.[68] A proper attack direction incorporated the element of surprise while providing ease of maneuver.[69] Always flying at low altitude, the attack aircraft's route was perilous if not planned properly.

The Attack course provided measures to mitigate threat exposure during the cruise portion of the mission.[70] The ideal route avoided all signs of life, but aircraft range limitations and the mere possibility of detection made this impractical.[71] Instead, planners focused on avoiding AAA installations, aircraft interception network reporting stations, ground combat zones, and enemy airfields. ACTS suggested AAA batteries were often associated with urban areas while aircraft interception network reporting stations were also located in urban areas and along lines of communication.[72] Unfortunately, these high threat areas provided the necessary landmarks pilots required for visual navigation. The Attack course taught useable landmarks for daylight and high illumination night operations included large bodies of water,

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[65] Stearley, "Tactics and Technique of Attack Aviation," 2.
[66]Stearley, "Attack Weapons. Chemicals and Chemical Dispersion," 3.
[67] Barnes, "Operations of Attack Aviation," 8.
[68] Barnes, "Operations of Attack Aviation," 4.
[69] Barnes, "Attack Itineraries," 4.
[70] Barnes, "Attack Itineraries," 5.
[71] Barnes, "Attack Itineraries," 2.
[72] Barnes, "Attack Itineraries," 2-3.

rivers, cities, railroads, paved roads, and hill masses. The only available landmarks during low illumination nights were manmade landmarks artificially lit such as cities, towns, and primary highways.[73] Planners also provided locations of friendly pursuit combat air patrols (CAPs) over friendly and enemy territory as well as any other airspace control measures required during transit.[74] In a time of limited radio communication, flight leads depended on thorough mission planning for effective flight discipline.[75]

Formation

The Air Corps used the foundation of the element to construct the appropriate-size attack formation for a given task. ACTS recommended the smallest formation for attacking the smallest target was an element. Individual aircraft in an element contained the same weapons load permitting all three aircraft to release weapons from the same altitude.[76] The normal formation for the element was the close "V" producing a weapons pattern of 220 yards or 73 yards between bombs; however, the element was flexible and could inflate the interval between aircraft to cover a wider target. Another tactic placed the element in echelon or trail to strike linear targets. The element leader relied on the pre-takeoff briefing and visual signals for in-flight control. The element provided some mutual support, but the limited offensive and defensive firepower usually drove the requirement for a larger formation.[77]

The flight was the smallest attack unit with sufficient offensive and defensive firepower for individual missions. A heterogeneously loaded flight, consisting of homogeneously loaded elements, possessed the capability to attack one area target or three separate targets utilizing

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[73] Barnes, "Attack Itineraries," 1.
[74] Capt Earl W. Barnes, "Attack Itineraries" lecture, Air Corps Tactical School, Maxwell AFB, AL, 17 January 1939, in AFHRA, decimal file no. 248.2208B-12, 4; Barnes, "Operations of Attack Aviation," 9.
[75] Barnes, "Operations of Attack Aviation," 4.
[76] Barnes, "Operations of Attack Aviation," 1-2.
[77] Barnes, "Operations of Attack Aviation," 2.

elements. The standard flight formation, an echelon of elements to the right or left, was a flexible and highly maneuverable formation capable of providing encompassing mutual support during any fighter attack. The flight commander, like the element leader, relied on the pre-takeoff briefing and visual signals for in-flight control, but also utilized radio communications in the absence of a squadron.[78]

The squadron was the smallest unit ACTS recommended for daylight operations in an area opposed by enemy fighters.[79] The standard squadron formation was an echelon with 300-foot intervals between flights during the cruise portion of the mission. The Attack course stressed the importance of the squadron maintaining a flat profile to prevent fighter attacks from below or aft of the formation. A squadron attack consisted of parallel or sequential flight attacks against either the same target or separate targets.[80] The squadron commander, unable to use visual signals, relied on the pre-takeoff briefing and radio communications for in-flight control; however, the Attack course expected combat operations to include radio silence, once again highlighting the importance of a thorough briefing and meticulous planning at the group level.[81] A group, consisting of four squadrons, rarely employed at full strength. A group commander only utilized as many squadrons as required to attack a target making a group attack merely separate squadron.[82] ACTS recommended formations remain as large as possible for as long as practicable in enemy pursuit areas.[83] In an evil twist, the Attack instructors lectured on attack missions tasked against the very threat attack aircraft were to avoid.

Counterair Missions

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[78] Barnes, "Operations of Attack Aviation," 3-4.
[79] Barnes, "Operations of Attack Aviation," 11.
[80] Barnes, "Operations of Attack Aviation," 4.
[81] Barnes, "Operations of Attack Aviation," 5.
[82] Barnes, "Operations of Attack Aviation," 5.
[83] Barnes, "Operations of Attack Aviation," 11.

The Attack course understood the dire situation AAA presented to the bombers. The ideal bombing probability altitude was in the heart of the modern AAA engagement zone, driving the bombers to higher altitudes. Higher altitudes decreased the bombing probability, requiring more bombers. The Air Corps wanted attack aircraft to suppress enemy AAA enabling the bombers to fly lower and acknowledged it would take a major war to determine if attack aircraft losses would be prohibitive.[84] The Attack course identified elements of AAA, ability of the gun crew to locate and follow the bomber, gun and crew precision, and intensity of fire, as vulnerable system elements.[85] The first mission of Counterair, known in the modern USAF as Suppression of Enemy Air Defenses, was to neutralize AAA so that bomber losses would be minimal.[86]

ACTS advocated the primary target in the AAA system was the battery, a challenging target. AAA units were small targets, widely scattered, and easily moved and camouflaged, making them difficult to find. Batteries remained silent and hidden until threatened, complicating the identification problem.[87] The Attack course recommended techniques for estimating battery locations based on defense geography.[88] Further compounding the problem, the Coast Artillery officer core recommended night tactics should focus on targeting searchlights. The Attack course recommended focusing on the batteries, arguing the guns fired on the bombers, not the searchlights.[89] The recommended ACTS weaponeering solution included armor piercing ammunition, 30-pound high-drag fragmentation bombs, and liquid

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[84] Capt Earl W. Barnes, "Illustrative Problem No. 3: Assault of AA Defenses (Night)" lecture, Air Corps Tactical School, Maxwell AFB, AL, 23 January 1939, in AFHRA, decimal file no. 248.2208B-14, 1.
[85] Barnes, "Illustrative Problem No. 3: Assault of AA Defenses (Night)," 1-2.
[86] Stearley, "Basic Principles of Employment," 2.
[87] Stearley, "Tactics and Technique of Attack Aviation," 9.
[88] Stearley, "Tactics and Technique of Attack Aviation," 10.
[89] Stearley, "Tactics and Technique of Attack Aviation," 15-16. ACTS explained there were too many searchlights for a flight to attack. A successful flight attack resulted in fewer searchlights cueing full strength batteries against the bombers.

chemical spray. The fragmentation bombs produced casualties and were likely to sever fire control unit cables while the chemical spray, preferably mustard gas mixed with tear gas, produced casualties and forced gun crews to don gas masks decreasing their efficiency.[90] The attack units had to find and neutralize the batteries before the lumbering bombers arrived overhead.

An effective AAA suppression rested on the coordination efforts between the bomber and attack units. The attack unit did not form up with the bombers, but coordinated their attack based on bomber routing and timing.[91] Bomber units supplied the attack unit with routes, altitudes, target locations, release points, and mission timing. Attack units used this information to plan the assault on the AAA batteries five minutes prior to the bomber attack.[92] The attack planner used the bomber routes and release points to plot the bomber lane. Using this information, the planner identified the AAA batteries the bombers needed silenced.[93] The size of the assault force depended on the number of factor batteries.

The final assault on AAA was a matter of locating the batteries and attacking them. The Attack course assigned an element to attack a single battery. The daytime AAA suppression standard utilized a flight against a two-gun battery. If unable to find the guns, the flight waited for the bomber formation to stimulate the AAA batteries. Once the flight located the batteries, the flight commander dispatched two elements to attack the individual batteries. The flight commander accomplished a re-attack if required.[94] Nighttime suppression operated in the same fashion, except the flight was minus an element for safety considerations,

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[90] Stearley, "Tactics and Technique of Attack Aviation," 12.
[91] Stearley, "Tactics and Technique of Attack Aviation," 9.
[92] Stearley, "Tactics and Technique of Attack Aviation," 3-4.
[93] Stearley, "Tactics and Technique of Attack Aviation," 9-10.
[94] Stearley, "Tactics and Technique of Attack Aviation," 10-11.

preventing a re-attack option.[95] Unfortunately, this easily explained task was a daunting challenge in practice as was evident in a 1938 example where attack aircraft failed to locate AAA batteries in an exercise, demonstrating the difficulty of the mission.[96] Airfields, on the other hand, were easier to locate.

The Air Corps considered grounded aircraft and the associated airfields a vulnerable target set.[97] An airfield included the runway as well as the organizations, installations, personnel, and materiel co-located with the runway. ACTS stressed the importance of attack aircraft over any other target on an airfield.[98] Counterair missions against airfields accomplished three goals. First, attacks permanently destroying aircraft reduced a belligerent's relative combat strength. Second, attacks temporarily damaging aircraft and airfield facilities reduced the general combat efficiency of a hostile air force. Finally, general harassment attacks interfered and disrupted enemy plans for specific and immediate operations.[99] Although ACTS focused on aircraft, airfields were target rich environments.

The possibility of the absence of aircraft dictated the Air Corps explore other targets on an airfield. Runways and taxiways made poor targets for demolition bombs because they were easy to repair; however, concentrated mustard gas on runways, taxiways, and parking areas may prevent flying operations for an extended period. ACTS suggested personnel made poor targets unless they were concentrated in areas such as headquarters buildings, mess halls, or billets making them vulnerable to machine gun fire fragmentation. The Attack course

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[95] Stearley, "Tactics and Technique of Attack Aviation," 13-14.
[96] Stearley, "Tactics and Technique of Attack Aviation," 17.
[97] Stearley, "Basic Principles of Employment," 2-4.
[98] Stearley, "Illustrative Problem No. 4: Day Attack on Airdromes," 2.
[99] Capt Ralph F. Stearley, "Illustrative Problem No. 4: Day Attack on Airdromes" lecture, Air Corps Tactical School, Maxwell AFB, AL, 25 January 1939, in AFHRA, decimal file no. 248.2208B-15, 1. All references to this lecture are found in Section VI of the Form II.

discouraged attacking supplies and munitions considering an adversary could easily protect and distribute them.[100] As the target set dwindled it became apparent ACTS wanted to attack aircraft. The instructors impressed upon the students the importance of accurate intelligence enabling attacks when enemy aircraft were present. When the attack came, ACTS recommended dispatching a squadron.[101]

The Attack course offered two methods of attack operations for airfields based on aircraft presence. The first method was to neutralize an airfield absent of aircraft preventing use for a finite period.[102] Each flight, loaded with mustard gas filled chemical spray tanks and "tin can" bombs, attacked a runway neutralizing it and denying enemy access with mustard persistence from the "tin can" bombs until the fields were decontaminated.[103] The second method focused on destroying aircraft and associated airfield targets. Aircraft weapons load included chemical spray tanks filled with mustard to contaminate aircraft, munitions, and supplies, 30-pound high drag fragmentation bombs to destroy aircraft, and armor-piercing ammunition with tracers to ignite aircraft fuel tanks. The two flights were echeloned with an aircraft interval of 50 to 75 yards enabling a heavy concentration of fragments and chemicals.[104] Successful Counterair missions provided a more permissive environment enabling attack aircraft to help the poor soldier marching through the mud.

Counterland Missions

In 1939, Counterland missions focused on interdiction target sets. The "Attack" text defined the ground support mission as operations designed to disrupt, neutralize, or destroy supply systems, LOCs, supply and manufacturing facilities, light bridges, transportation equipment,

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[100] Stearley, "Illustrative Problem No. 4: Day Attack on Airdromes," 2-3.
[101] Stearley, "Tactics and Technique of Attack Aviation," 2-3.
[102] Stearley, "Tactics and Technique of Attack Aviation," 3.
[103] Stearley, "Tactics and Technique of Attack Aviation," 6.
[104] Stearley, "Tactics and Technique of Attack Aviation," 7.

and troop concentrations.[105] To accomplish this mission set, attack assets needed to operate from small fields closer to the ground forces to enhance close cooperation.[106] Close cooperation included a thorough understanding of the ground scheme of maneuver to prevent fratricide and aid attack planning.[107] ACTS recommended using a rudimentary fire support coordination line (FSCL) to separate the ground and air commanders' areas of responsibility.[108] In the eyes of the Air Corps, anything beyond this agreed upon line was fair game.

Railroads were still the backbone of the military ground transportation system and were more vulnerable to attack and difficult to repair than highways.[109] A massed army of 60 divisions required 20,000 freight cars, making railroads an ideal target to persistently attack.[110] The Attack course, using the German example of 144 trains a day flowing into Belgium at the beginning of WW I, suggested a successful air interdiction campaign against railroads could defeat an enemy before the conflict began.[111] Rail networks were extensive making comprehensive defense impracticable.[112] Learning from B.H. Liddell Hart's observation of WW I, the Attack course recommended hammering the rail network early and hammering it often.[113]

Modern repair methods required creative and persistent weaponeering. Railroad workers repaired rail line breaks in less than 24 hours, but it took them 7 to 9 days to repair bridges.[114] ACTS assumed

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[105] Stearley, "Tactics and Technique of Attack Aviation," 18.
[106] Stearley, "Basic Principles of Employment," 9.
[107] Capt Earl W. Barnes, "Illustrative Problem No. 6: Attack of Troops on the Road" lecture, Air Corps Tactical School, Maxwell AFB, AL, 31 January 1939, in AFHRA, decimal file no. 248.2208B-17, 2.
[108] Stearley, "Basic Principles of Employment," 4.
[109] Stearley, "Tactics and Technique of Attack Aviation," 18.
[110] Capt Earl W. Barnes, "Illustrative Problem No. 8: Cutting of Rail Lines of Communication" lecture, Air Corps Tactical School, Maxwell AFB, AL, 6 February 1939, in AFHRA, decimal file no. 248.2208B-19, 2.
[111] Barnes, "Illustrative Problem No. 8: Cutting of Rail Lines of Communication," 6.
[112] Barnes, "Illustrative Problem No. 8: Cutting of Rail Lines of Communication," 1.
[113] Barnes, "Illustrative Problem No. 8: Cutting of Rail Lines of Communication," 3-4.
[114] Barnes, "Illustrative Problem No. 8: Cutting of Rail Lines of Communication," 8-11.

light wooden bridges were numerous and difficult to defend making them the priority rail target. The priority target for the railroad target set was the light bridge because it offered the longest repair delay.[115] The preferred weapon solution utilized 100-pound delay-fuzed demolition bombs to destroy the bridge and mustard filled "tin can" bombs forcing the repair crew to wear protective gear and to decontaminate the area before beginning repairs.[116] The Attack course also recommended using a squadron with the same weapons load to break a rail line in six locations, preferably in an unpopulated location over a distance of 30 to 40 miles adding to the repair timeline.[117] The rapid pace of technological advancements provided other avenues of approach for ground forces.

Mechanized columns, truck columns, and marching columns presented as linear targets.[118] The Attack course designed all linear attacks on the basic planning factor of one element per mile enabling an element to cover five to seven miles.[119] The standard weapons load for linear targets was armor-piercing ammunition, 30-pound high drag fragmentation bombs, and mustard spray.[120] Tests demonstrated 20 fragmentation bombs were more effective than four 100-pound demolition bombs against armored columns.[121] ACTS recommended halting the column by attacking the forward elements in echelon from the side with all elements striking near simultaneously limiting aircraft vulnerability from surface fire and inter-flight fratricide issues.[122] Before a column became a linear target, it concentrated in the form of an area target.

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[115] Barnes, "Illustrative Problem No. 8: Cutting of Rail Lines of Communication," 13; Stearley, "Tactics and Technique of Attack Aviation," 18.
[116] Stearley, "Tactics and Technique of Attack Aviation," 19.
[117] Stearley, "Tactics and Technique of Attack Aviation," 19-20.
[118] Stearley, "Tactics and Technique of Attack Aviation," 20.
[119] Stearley, "Tactics and Technique of Attack Aviation," 3.
[120] Stearley, "Tactics and Technique of Attack Aviation," 21.
[121] Stearley, "Tactics and Technique of Attack Aviation," 23.
[122] Stearley, "Tactics and Technique of Attack Aviation," 22, 25.

The Attack course identified factory areas, ammunition and supply dumps, and troops as area targets. The preferred method of attack for area targets excluding troops included utilizing 100-pound demolition bombs complimented with "tin can" bombs with aircraft in line or in echelon.[123] The guiding principle for attacking troops was to locate and attack large concentrations in. ACTS recommended deployed troops were unsuitable targets.[124] Concentrated troops were located in rear areas beyond artillery range in bivouacs, columns, and disembarking from landing transports.[125] The preferred method of attack for troops included utilizing 30-pound high-drag fragmentation bombs and chemical spray in echelon.[126] The Attack course recommended troops in a mobile column were attacked utilizing a deliberately plan for slow moving troops with a well-defined route, a partial plan for troops under constant observation, or a dynamic plan using armed recce tactics.[127] Enemy troops were vulnerable when concentrated in another form of mobile column as well.

ACTS advocated attack aircraft were the last line of defense for an enemy seaborne invasion. The Air Corps, using long-range bombers, assumed a naval invasion force would never be in a position to launch a beach assault and further suggested an invasion force, to be successful, required a land-based air force to support the invasion.[128] The Attack course suggested an air-opposed beach landing was a suicidal affair, but acknowledged the possibility existed, requiring attack units to prepare for such an invasion.[129] Stearley considered a beach invasion against the United States a decisive point requiring the use of the entire Air

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[123] Stearley, "Tactics and Technique of Attack Aviation," 20-21.
[124] Barnes, "Illustrative Problem No. 6: Attack of Troops on the Road," 1.
[125] Barnes, "Illustrative Problem No. 6: Attack of Troops on the Road," 1.
[126] Stearley, "Tactics and Technique of Attack Aviation," 20.
[127] Barnes, "Illustrative Problem No. 6: Attack of Troops on the Road," 3.
[128] Capt Earl W. Barnes, "Operations of Attack Aviation in a Beach Landing" lecture, Air Corps Tactical School, Maxwell AFB, AL, 8 February 1939, in AFHRA, decimal file no. 248.2208B-21, 1.
[129] Stearley, "Basic Principles of Employment," 4.

Corps' attack force.[130] The Attack course explored both coastal defense and offensive operations in support of a beach landing.

The Attack course divided the coastal defense mission into three phases. The initiation of the first phase occurred when troop transports arrived off the target beaches and began trans-loading troops to small landing craft. In this phase, attack aircraft, loaded with 100-pound demolition bombs and "tin cans" filled with mustard or tear gas, attempted to sink the troop transports and inflict as many casualties as possible.[131] A non-permissive environment and enemy assault timing may prohibit attack operations in the phase.[132] The second phase began when landing craft assaulted the beach. The Attack course failed to provide a weapons load-out for this phase, but did recommend attacking landing craft or troops disembarking from the landing craft.[133] Phase 3 operations included interdicting supplies on the beach once a beachhead was established. Assuming naval AAA protected the supply ships, the Attack course recommended focusing on using chemicals to contaminate supply dumps on the beach.[134] Perhaps foreshadowing the future, the Attack course used coastal defense tactics to develop offensive tactics and techniques in support of friendly beach invasion.

The Attack course instructors thought a friendly beach invasion benefited from both Counterair and Counterland missions. Prior to Phase 1 operations discussed above, ACTS envisioned tasking attack aircraft against enemy airfields using both the neutralization and destruction tactics described in the Counterair missions section of this

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[130] Stearley, "Tactics and Technique of Attack Aviation," 8.
[131] Barnes, "Operations of Attack Aviation in a Beach Landing," 14; Stearley, "Tactics and Technique of Attack Aviation," 8.
[132] Barnes, "Operations of Attack Aviation in a Beach Landing," 15.
[133] Barnes, "Operations of Attack Aviation in a Beach Landing," 17. Neither this lecture or "Tactics and Technique of Attack Aviation" specifically address weapons for this tactic. The author infers the Attack course would have recommended 30-pound fragmentation bombs and chemical spray.
[134] Barnes, "Operations of Attack Aviation in a Beach Landing," 17-18.

chapter.[135] The Attack course struggled with the proper use of attack aircraft during Phase 2 operations. Instructors suggested attack aircraft could create a smoke screen to cover friendly landing craft, but poor weather conditions could hinder instead of help the assault force.[136] Unable to use chemicals, instructors also suggested attack aircraft, loaded with fragmentation bombs, could neutralize light artillery and machine guns defending the beach.[137] Defaulting to the rudimentary FSCL, the Attack course advised priority missions during Phase 2 should focus on interdicting the adversary's reserves using troop column tactics previously discussed.[138] Ignoring the attack mission sets was a luxury the commander, staring at a perilous coastline, did not have.

Conclusion

ACTS struggled with its attack aviation identity, which was systemic of a larger Air Corps identity problem. After all, Germany was the only WW I belligerent who recognized the necessity for a specialized attack aircraft.[139] Stearley highlighted Counterair missions were the responsibility of the GHQ Air Force, but failed to mention anything about the Counterland mission chain of command. In an attempt to avoid the matter, ACTS actually suggested assigning attack aircraft to National Guard units subsequently assigned to corps or divisions. In this scenario, the Air Corps' attack assets conducted the Counterair mission set while the National Guard assets conducted the Counterland missions.[140] This suggestion never gained momentum and, more importantly, the Army never developed the appropriate mechanisms required to integrate ground units with the air units supporting them

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[135] Barnes, "Operations of Attack Aviation in a Beach Landing," 8.
[136] Barnes, "Operations of Attack Aviation in a Beach Landing," 8.
[137] Barnes, "Operations of Attack Aviation in a Beach Landing," 12.
[138] Barnes, "Operations of Attack Aviation in a Beach Landing," 12.
[139] Barnes, "The Attack Airplane," 2.
[140] Stearley, "Basic Principles of Employment," 10; Stearley, "History, Development, Organization, Training," 10.

before the outbreak of war.[141] Even interdiction missions needed to be coordinated with the ground forces to ensure airpower did not interfere with the scheme of maneuver. An established measure such as a fire support coordination line could have created an environment forcing the Army and its Air Corps to develop procedures for air-ground coordination. Instead, the Air Corps stressed the importance of a bigger, less maneuverable aircraft.

ACTS instructors believed attack aircraft were the most efficient Counterair weapon the air force commander possessed, at least until bombardment adopted low altitude tactics and added chemical weapons to its arsenal.[142] This meant attack aircraft needed the range and speed of the bombers.[143] The two-engine attack aircraft materialized in the form of the A-20, but could not fulfill the spectrum of attack missions. The A-20 worked well for the interdiction and airfield mission sets, but was ill suited for AAA suppression or close air support.[144] A big bomber proved industry was capable of producing engineering marvels, but ACTS failed to envision the aircraft requirements needed for the complete attack mission set. The Attack section may have struggled with aircraft, but still managed to produce sound interdiction doctrine.

The Attack course, for all its shortcomings, was the unsung hero of the ACTS syllabus. Unlike the bombers, the attack aircraft was incapable of performing its mission set because of a lack of a capable aircraft; however, it had identified valid target sets and developed methods capable of producing the desired effect. The Counterland doctrine and tactics developed during the interwar period at ACTS was the only serious thought devoted to the subject by any higher agency in the Army and its Air Corps. The thought devoted to this one target set

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[141] Richard R. Muller, "Close Air Support: The German, British, and American Experiences, 1918-1941," in *Military Innovation in the Interwar Period*, ed. Williamson Murray and Allan R. Millett (Cambridge, UK: Cambridge University Press, 1998), 185.
[142] Stearley, "Basic Principles of Employment," 3.
[143] Stearley, "Basic Principles of Employment," 7.
[144] Muller, "Close Air Support," 180.

provided the necessary means to soften up beaches and limit enemy ground forces resistance.

Conclusions

Proficimus More Irrententi: We Make Progress Unhindered by Custom.

ACTS Motto

ACTS theory and doctrine were as mature as they were going to get when the class of 1938-1939 graduated. Instructors were already condensing courseware for the new short courses, and there would be little time for new thinking. The interwar years were a turbulent time for the Air Corps and its Tactical School. Airpower was still in its infancy and American foreign policy was one of isolationism, meaning a small service with a small budget. Always the innovators, ACTS managed to develop doctrine on a small budget that contributed to victory in the largest war of human history. Not every bomber made it through, but enough of them did. Airpower was not decisive by itself, but its absence would have decisively defeated the Allies. The theory and doctrine of ACTS was by no means perfect, but how could it be until it descended into the crucible of war?

ACTS Report Card: A Quick Look at WW II

The first dispatch of American airpower came in the form of 16 heavy-bombardment groups, three pursuit groups, and eight reconnaissance squadrons.[1] The bomber force alone was five times the size of the Air Corps' bomber force in 1939. Luckily, the illustrative problems and map problems of the Bombardment course had prepared a cadre of officers capable of commanding and staffing the rapidly expanding Army Air Force. The doctrine derived during the Air Force course serves as an adequate lens to explore ACTS contributions to WW

[1] Richard G. Davis, *Carl A. Spaatz and the Air War in Europe* (Washington, D.C.: For sale by the Supt. of Docs., U.S. G.P.O, 1993), 71.

II. The topics discussed in the Bombardment and Attack courses bring the lens into focus.

Strategic Attack

A recurring theme throughout the Air Force and Bombardment courses was that so much remained unknown. Fairchild predicted a state's national economic structure was vulnerable to attack, but knew an extensive analysis of specific states would be required to identify the key vulnerabilities, a luxury the Allies did not have prior to the outbreak of war. Kuter predicted massive armadas of bombers would be required for NES attack, but struggled with incomplete weaponeering and accuracy data, making it extremely difficult to develop an air campaign plan. Yet, when war came, the aspirational Air Force course provided theory and doctrine for the Army Air Forces (AAF) to draw upon, while the creativity of the Bombardment course molded the shape of American airpower. The maturity of the ACTS syllabus, with all of its unknowns, informed AWPD-1, and had at least reduced the number of unknowns American airmen faced as they deployed to the British isles in the fall of 1942.[2]

Early American strategic attack efforts failed to follow Fairchild's prescriptions from the Air Force Course. Fairchild explored both the oil and steel industries, recommending them as viable target sets, but had settled on the electric power industry as the key node necessary to operate all other industries. The Casablanca conference, held in January 1943, directed the AAF and the RAF to destroy the German military, industrial, and economic systems progressively.[3] This directive, scoped broadly, enabled the AAF to implement the recommendations of Fairchild's NES attack scheme. Unfortunately, Lieutenant General Ira C.

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[2] Maj Gen Haywood S. Hansell, Jr., *The Air Plan that Defeated Hitler* (Atlanta, GA: Higgins-McArthur/Longino and Porter, Inc., 1972), xi, 98.
[3] Tami Davis Biddle, *Rhetoric and Reality in Air Warfare: The Evolution of British and American Ideas About Strategic Bombing, 1914-1945* (Princeton, NJ: Princeton University Press, 2002), 215.

Eaker, concerned with air superiority, elected to focus on the aircraft industry.[4] The Combined Bomber Offensive (CBO) planning team, an international panel consisting of AAF and RAF members, agreed the top three priorities should be the aircraft industry, submarine industry and bases, and ball bearings.[5] This decision, discussed in further detail in the Counterair section below, prevented implementing ACTS-envisioned strategic bombing until early 1944.

The NES attack ideas promulgated through the Air Force course finally became evident during the spring of 1944. General Carl A. Spaatz, commander of the United States Strategic Air Forces in Europe, zeroed in on the German synthetic oil production industry in the months leading up to the Allied invasion of France. Intercepted German communications confirmed the strategic nature of this target set. Albert Speer, the German Minister for Armaments and War Production, expressed his concerns to Hitler and suggested Allied bombing efforts had located a weakness that, if exploited, would result in negligible fuel production capacity.[6] Reflecting years later, Speer wrote about 12 May 1944, "on that day the technological war was decided."[7] Relying on a target set recommended by ACTS, Spaatz had selected a compact, crucial, and vulnerable target set, bombed it relentlessly, and eliminated an unknown from the Air Force course. Spaatz's bombers grounded the Luftwaffe and commandeered the mobility of the Wehrmacht, ending the war months earlier than it otherwise would have without bombing this target set.[8]

By the end of WW II, the CBO attack against the German economic structure had paid off. Ultimately, the Americans focused on two of the three primary target sets recommended in the Air Force course. The

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[4]Biddle, *Rhetoric and Reality in Air Warfare*, 216.
[5] Hansell, Jr., *The Air Plan that Defeated Hitler*, 163.
[6] Davis, *Carl A. Spaatz and the Air War in Europe*, 398.
[7] Hansell, Jr., *The Air Plan that Defeated Hitler*, 221.
[8] Davis, *Carl A. Spaatz and the Air War in Europe*, 596.

attacks on both the oil and steel industries were effective because they were highly capital-intensive with few opportunities for effective dispersal.[9] After the war, Speer vindicated Fairchild's electric power hypothesis by arguing the Reich's electric power grid was highly vulnerable to attack. Unfortunately, Spaatz and his staff believed the grid to be more developed and robust than it actually was, an unknown the Allies failed to explore completely.[10] Fairchild would also get a definition for his term "pressure" as the war wound down.

The true mechanism of bombing success was the "pressure" the CBO exerted on the economy and the overall German strategy. German industrial production increased in 1944, but at a much slower rate due to the CBO. Bombing placed a cap on German production well below actual German capacity. Bombers forced the Germans to shift artillery production to AAA instead of anti-tank artillery, easing the Russian advance on the eastern front. Most importantly, the CBO destroyed Germany's freedom to plan war production without interruption, never achieving a constant stream of war materiel.[11] By 15 March 1945, Speer reported to Hitler the collapse of the German economy was inevitable and would happen within four to eight weeks.[12] The Air Force course had successfully predicted a state's economy could not withstand the "pressure" of strategic bombing. NES attack did not equate to killing innocent civilians.

By 1939, ACTS had shed any preconceived notions about indiscriminately bombing civilian populations, a concept often misunderstood. Tami Davis Biddle, in *Rhetoric and Reality in Air Warfare*, used evidence from the mid-1930s to illustrate her claim: "they

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[9] Richard J. Overy, *The Air War, 1939-1945* (Washington, D.C.: Potomac Books Inc., 2005), 122.
[10] Biddle, *Rhetoric and Reality in Air Warfare*, 276; Hansell, Jr., *The Air Plan that Defeated Hitler*, 286-297. Appendix III provides a thorough post-war assessment of Germany's electric power grid independent of Speer's comments.
[11] Overy, *The Air War, 1939-1945*, 123.
[12] Hansell, Jr., *The Air Plan that Defeated Hitler*, 250.

usually found themselves conflicted and confused about it, and they avoided raising the moral or psychological effects of bombing to a privileged rhetorical position."[13] Biddle focused on the 1934-1935 "Air Force" text that examined attacking population centers and attacking targets "upon which the social life of the nation depends for its existence."[14] ACTS reversed its position on population bombing while Biddle misinterpreted the "social life of the nation" target set. Fairchild clearly stated ACTS did not endorse civilian population bombing and provided three reasons to support the official ACTS position. Civilian populations still needed to suffer, but they did not need to die.[15] The primary second order effect of attacking a state's NES was to cause civilian suffering as the civilian and war economies shared the same essential services. This second order effect was the method in which ACTS recommended to "pressure" a civilian population. In a related manner, Biddle contested both the RAF and the Air Corps bomber advocates' general objective was to undermine the enemy's will to fight by bombing an enemy's vulnerable points.[16] Actually, the 1939 Air Force course suggested the primary objective was to bring the war machine to a grinding halt, which affected both an adversary's ability and will to fight.[17] The Bombardment course developed an innovative planning method to accomplish these objectives.

The bombing probabilities class taught in the Bombardment course may have been the principal contribution ACTS made to the war effort. Hitting a target was much harder than selecting one and Kuter made sure everyone knew it. Biddle, claiming the Air Corps lacked an appetite for strategic intelligence, suggested America's preoccupation with the science behind planning could not resolve all of the

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[13] Biddle, *Rhetoric and Reality in Air Warfare*, 159.
[14] Biddle, *Rhetoric and Reality in Air Warfare*, 159.
[15] Maj Muir S. Fairchild, "The National Economic Structure," lecture, Air Corps Tactical School, Maxwell AFB, AL, 5 Apr 1939, in AFHRA, decimal file no. 248.2020A-9, 3-6.
[16] Biddle, *Rhetoric and Reality in Air Warfare*, 162.
[17] Fairchild, "The National Economic Structure," 6.

shortcomings inherent in the planning process.[18] The Air Corps knew it still had a long way to go, but Kuter's infatuation with the numbers was pivotal to the rapid Air Corps expansion. Not only did the bombing probabilities class give General Henry "Hap" Arnold the ammunition he needed to justify acquiring thousands of bombers, it provided a sound scientific base for the "Big Business". The CBO proved that planning an air campaign was just as intellectually demanding as planning any land or naval campaign.[19]

Both the AAF and the RAF entered the war behind the power curve. Kuter provided a humbling and frustrating image of an Air Corps with a "sorry" bombing history.[20] The RAF was in worse shape. Unlike the Air Corps, the RAF had accomplished little work in finding an effective method for implementing a bombing campaign.[21] The RAF quickly learned, as ACTS had already highlighted to the Air Corps, weaponeering skills and valid accuracy data was crucial to assess the weapon and bomber requirements for a given mission.[22] Data availability plagued both services before the war and continued to hinder the RAF's effectiveness in 1941 and 1942.[23] Fortunately, as the years progressed, data collection and analyses matured. Organizations, such as the RAF's Operational Research Section, using foundational methods derived at ACTS, aided Allied air forces and contributed to better bombing effectiveness in the later years of the war.[24]

Counterair

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[18] Biddle, *Rhetoric and Reality in Air Warfare*, 164.
[19] Randall T. Wakelam, *The Science of Bombing: Operational Research in RAF Bomber Command* (Toronto: University of Toronto Press, Scholarly Publishing Division, 2009), 231.
[20] Capt Lawrence S. Kuter, "Practical Bombing Probabilities: Conclusion" lecture, Air Corps Tactical School, Maxwell AFB, AL, 13 February 1939, in AFHRA, decimal file no. 248.2208A-7 Part 4, 10.
[21] Wakelam, *The Science of Bombing*, 15.
[22] Wakelam, *The Science of Bombing*, 187.
[23] Wakelam, *The Science of Bombing*, 49.
[24] Wakelam, *The Science of Bombing*, 227.

Defeating the Luftwaffe proved to be a daunting task. Eaker's efforts in 1943 focused on the aircraft industry, a strategic attack target set, completely disregarding the synergistic prescriptions of the Air Force and Attack courses. Eaker hoped the bombers would attrit enemy fighters in the air, ignoring the airfields the fighters came from.[25] The Bombardment course highly recommended fighter escort and feared the absence of a long-range fighter. Snavely expected massive losses on days fighters intercepted a bomber formation and expected low interception rates.[26] He failed to predict the use of early warning radar, for which no one can fault him given the rapid development of this system after 1939.[27] The high technology Air Corps was now on the receiving end of a high technology Luftwaffe.

Air superiority came in 1944 after Spaatz directed a strategy commensurate with the synergistic effects of ACTS Counterair doctrine.[28] Spaatz differed with Eaker in that he wanted to attack the Luftwaffe in the factories, in the air, and on the ground. Spaatz, reinforced with his Tunisian experience, validated the Attack course's recommendation for attacks on airfields.[29] The urgency for air superiority also stemmed from the impending invasion. As the Attack course instructed, the Allies feared the invasion could falter in the presence of the Luftwaffe.[30] In the months leading up to D-Day, bombers and fighters attacked airfields in Germany and France while long-range escorts pummeled the Luftwaffe baited by large bomber formations.[31] The predicted battle for air

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[25] Biddle, *Rhetoric and Reality in Air Warfare*, 216.
[26] Capt Ralph A. Snavely, "Bombardment with Pursuit Opposition" lecture, Air Corps Tactical School, Maxwell AFB, AL, 1 March 1939, in AFHRA, decimal file no. 248.2208A-21, 4, 20.
[27] Davis, *Carl A. Spaatz and the Air War in Europe*, 30-31.
[28] Davis, *Carl A. Spaatz and the Air War in Europe*, 345.
[29] Davis, *Carl A. Spaatz and the Air War in Europe*, 301.
[30] Capt Ralph F. Stearley, "Basic Principles of Employment" lecture, Air Corps Tactical School, Maxwell AFB, AL, 3 January 1939, in AFHRA, decimal file no. 248.2208B-1, 4. Note: this lecture is in the same file as "History, Development, Organization, Training".
[31] Davis, *Carl A. Spaatz and the Air War in Europe*, 410-411.

superiority over the beaches of France never happened courtesy of Counterair operations envisioned by ACTS.[32]

Counterland

The Attack course, more than any other course, got it right. The interdiction campaign leading up to Overlord and continuing until the Allies arrived in Berlin mirrored the prescriptions of the Attack course. The plan offered to General Dwight D. Eisenhower by Spaatz recommended attacking road and rail LOCs in rural areas, supply and ammunition dumps, and armor concentrations. Eisenhower made a controversial change to this plan, directing Spaatz to attack rail yards in urban areas. Spaatz feared attacking urban rail yards would produce an unacceptable level of collateral damage, thousands of innocent French civilians, but executed his orders.[33] Bridges along the road and rail LOCs, the key vulnerabilities identified at ACTS, became a priority target set for both fighters and the heavy bombers.[34] Finally, Allied airpower attacked moving trains. These efforts severely limited the Germans' ability to respond to the invasion.[35] When the Allied ground forces finally encountered German resistance, they wanted close air support, the one mission the Attack course did not address.

The flexibility of airpower enabled fighters and bombers to provide close air support, but a lack of established liaison and control procedures limited Allied airpower effectiveness. The Army and it Air Corps were hopelessly separated as operations commenced in Northern Africa. American action in both Tunisia and Sicily highlighted American shortcomings, and ACTS failure to provide doctrine and tactics forced the AAF to look to the RAF for an effective system.[36] Major General Pete

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[32] Davis, *Carl A. Spaatz and the Air War in Europe*, 414.
[33] Davis, *Carl A. Spaatz and the Air War in Europe*, 401.
[34] Davis, *Carl A. Spaatz and the Air War in Europe*, 408.
[35] Davis, *Carl A. Spaatz and the Air War in Europe*, 410-411.
[36] Richard R. Muller, "Close Air Support: The German, British, and American Experiences, 1918-1941," in *Military Innovation in the Interwar Period*, ed. Williamson

Quesada managed to build an effective relationship with American ground forces in a precursor to modern CAS tactics and techniques during the journey from Normandy to the Elbe.[37] His example was the exception more than the rule. In the Pacific, Lieutenant General George C. Kenney, the most innovative airmen of WW II and a former Attack course instructor, reluctantly provided CAS, but never embraced the mission. He firmly believed it was a waste of aircraft to execute CAS missions.[38] The reluctance of the establishment limited the ability to develop robust doctrine often leading to ineffective support and fratricide.[39] At the other end of the spectrum, the AAF was ready to sink boats.

Countersea

Obliging the Air Corps leadership and paying homage to the pioneers, ACTS ensured the Countersea mission set was prominent in the syllabus. Beginning with Billy Mitchell in 1921, airmen introduced airpower as a cheaper, less offensive means of defending America against foreign invasion.[40] While not the preferred target set of ACTS, defending America against a foreign naval invasion was the excuse the Air Corps needed to buy big four engine bombers. Pictures of battleships sunk by the Air Service in 1921 culminated Kuter's weaponeering class. Needless to say, the AAF knew how to sink ships. In the Mediterranean between July 1942 and May 1943, Allied airpower was responsible for 46 percent of the Axis merchant shipping sunk, a vulnerable target set in the eyes of

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Murray and Allan R. Millett (Cambridge, UK: Cambridge University Press, 1998), 186-187.

[37] Thomas Alexander Hughes, *Over Lord: General Pete Quesada and the Triumph of Tactical Air Power in World War II* (New York: Free Press, 1995), 162-163, 302-303.

[38] Thomas E. Griffith Jr., *MacArthur's Airman: General George C. Kenney and the War in the Southwest Pacific* (Washington, D.C.: University Press of Kansas, 1998), 92.

[39] Colin S. Gray, *Airpower for Strategic Effect* (Maxwell AFB, AL: Air University Press, 2012), 131.

[40] Michael S. Sherry, *The Rise of American Air Power: The Creation of Armageddon* (New Haven, CT: Yale University Press, 1987), 34-35.

the instructors of the Air Force, Bombardment, and Attack courses.[41] The Army Air Forces also provided four engine long-range bombers for anti-submarine operations in the Atlantic, a task ACTS also addressed in the Bombardment course.[42] In the Pacific, one of Kenney's primary tasks was to attack Japanese shipping. Throughout his tour, Kenney used two engine and four engine bombers to attack vessels resupplying Japanese-infested islands.[43] AAF land based bombers never sunk a battleship in WWII; however, the Japanese Navy did. In December 1941, Japanese two-engine land based bombers sunk the Royal Navy's battleship *Prince of Wales* and the battle cruiser *Repulse* off the coast of Malaya, half a world away from the watery grave of the *Ostfriesland*, an example Kuter provided during the Bombardment course.[44] One can only imagine the satisfaction (and annoyance) Mitchell must have felt watching from the sidelines.

Final Thoughts: The Transcendence of ACTS

The ACTS syllabus did not use current USAF doctrinal terms, but described concepts still prevalent in the USAF today. Anyone familiar with current doctrine would instantly see the parallels between ACTS "outlaw" doctrine and the official doctrine now published by the LeMay Center. These parallels made it easy to classify and describe in terms modern airmen understand. Doctrine has evolved over the past 70 years, but builds upon the ACTS syllabus. For example, interdiction is still a crucial portion of Counterland doctrine, but the USAF embraced and incorporated the close air support mission to better support friendly ground forces. Counterair doctrine matured into a complementary mix of missions to address air-to-air threats and surface-to-air threats while incorporating surface attack missions. Strategic Attack, as it should be,

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[41] Overy, *The Air War, 1939-1945*, 70.
[42] Overy, *The Air War, 1939-1945*, 70-71.
[43] Griffith Jr., *MacArthur's Airman*, 74, 82.
[44] Mark R. Peattie, *Sunburst: The Rise of Japanese Naval Air Power, 1909-1941* (Lawrence, KS: Naval Institute Press, 2007), 168-170.

continues to be controversial. Nothing embodies this more than the next generation bomber.

The USAF continues to rely on high technology aircraft to provide the asymmetric advantage the Allies worked so hard to acquire in WW II. ACTS embraced the four-engine bomber, wanted a more capable attack platform, but was complacent about a long-range escort. The current USAF continues to focus on aircraft capable of dropping bombs, even with the air-to-air mission. The F-16, designed to out-maneuver the most advanced Russian fighters, can carry a heavier bomb load than a B-17. The F-22, America's most advanced air-to-air platform, also can carry bombs and replaced an aircraft only configured for air-to-air. The USAF continues its quest for a self-escorting bomber. The stealth technology of the B-2 is the latest effort. USAF senior leaders are currently discussing requirements for a penetrating bomber that will replace the B-52. These new state-of-the-art aircraft are meaningless without airmen who understand how to use them.

ACTS' most enduring contribution to the USAF is the value of training and education. Training and education institutions enable an organization to evolve. Without ACTS, the Air Corps would have been completely unprepared for WWII. From the ashes of ACTS, a phoenix of four schools arose. The Air War College, Air Command and Staff College, and Squadron Officer School are direct descendants of ACTS. The Weapons School embodies everything the faculty wanted ACTS to be. Combined, these four schools produce the most professional air force in the world, providing the US Government the asymmetric advantage envied by every other state, just as Fairchild envisioned in 1939.

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